10.000 DWT Coal Vessel/Barge Open Pier Jetty Planning at Molotabu, Gorontalo

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***Abstract*—Coal exports and imports are common in Indonesia, especially Gorontalo, North Sulawesi, which is always involved in coal export and import activities. Coal is one of the important energy sources in this country. These activities always involve ships. A ship certainly needs a station like any other form of transportation. Open pier construction has various regulations so that vessel can dock safely. Various things can affect the dimension and even the strength of the port structure. From the planning of the pier, implementation methods are also carried out to calculate the planned cost budget The results of planning an open pier jetty for a 10,000 DWT barge include a minimum depth recommendation of -6.5 mLWS. Recommended jetty dimensions are 108 m long and 20 m wide at an elevation of +2.5 mLWS. From the results of the upper structure calculations, a plate with a thickness of 35 cm was obtained. Then for the beam requirements for the jetty structure (500 x 750 mm) and fender beams (2600 x 2500 x 1200 mm). For single pile cap required (2000 x 2000 x 1000 mm) and batter pile cap (3000 x 2000 x 1000 mm). From the results of the substructure calculations, it was found that D609 mm steel piles with a thickness of 12 mm were needed for the jetty structure. Dredged volume requirement is 20,300 m3. Breast wall dimensions (400 x 2000 mm), cantilever dimensions (150 x 250 mm), foot dimensions (2500 x 400 mm), and stiffener thickness of 30 cm. From the overall calculation results, the implementation method can be planned as follows. Preparatory work, dredging work, retaining wall work, jetty structure work, and fender and bollard installation work. From this work, the total cost required is Rp. 51.324.256.809.**

***Keywords*—Cost Estimating, Dredging, Jetty, Open Pier, Retaining Wall.**

I. INTRODUCTION

COAL is Indonesia's most vital mining commodity. One form of utilization of coal is as a source of energy for power generation. Indonesia itself is one of the largest thermal coal producers and exporters in the world. Based on the Ministry of Energy and Mineral Resources website, Indonesia has coal resources of 143.7 billion tons. The availability of such large natural resources of coal can provide its own advantages, especially if the raw minerals are processed domestically. Therefore, the presence of coal is still very much needed in Indonesia, considering that this fossil fuel provides many benefits for humans.

To support the potential of Gorontalo and its surroundings which have many advantages because it is close to the Philippines and international traffic (sea transportation) is quite busy. Besides, the potential in the fields of industry and trade is racing against each other in the economic development of the Manado-Bitung Integrated Economic Development Zone (KAPET). However, these developments must be accompanied by the availability of adequate electricity.

In order to fulfill as well as to support the rapid development of the waters in Gorontalo and its surroundings, the construction of Jetty Port complete with mooring facilities for 10.000 DWT coal barges at Molotabu, Gorontalo, as operational fuel for the Power Plant must be carried out and the design based on [1-13].

Figure 1. Location of planning.

II. RESEARCH METHOD

A. Location of Research

The location of this jetty planning is in the North of Sulawesi, Molotabu, Gorontalo, with the detail of location can be seen on Figure 1.

B. Flow Chart

Flow chart of this planning can be seen on Figure 2.

C. Collecting and Data Analysis

Collected data analyzed based on [1].

1) Tides Data

Phenomenon of periodic ups and downs of sea levels caused by a combination of gravity and the attractive force of astronomical objects, especially the sun and the moon on the earth. The tides data result can be seen on Table 1.

2) Bathymetry Data

Bathymetric maps are maps that show contours seabed depth from the position of 0.00 mLWS. Bathymetry map at Molotabu, Gorontalo, can be seen on Figure 3.

From the results of observing currents around the location, the maximum current speed is 0,5 m/s

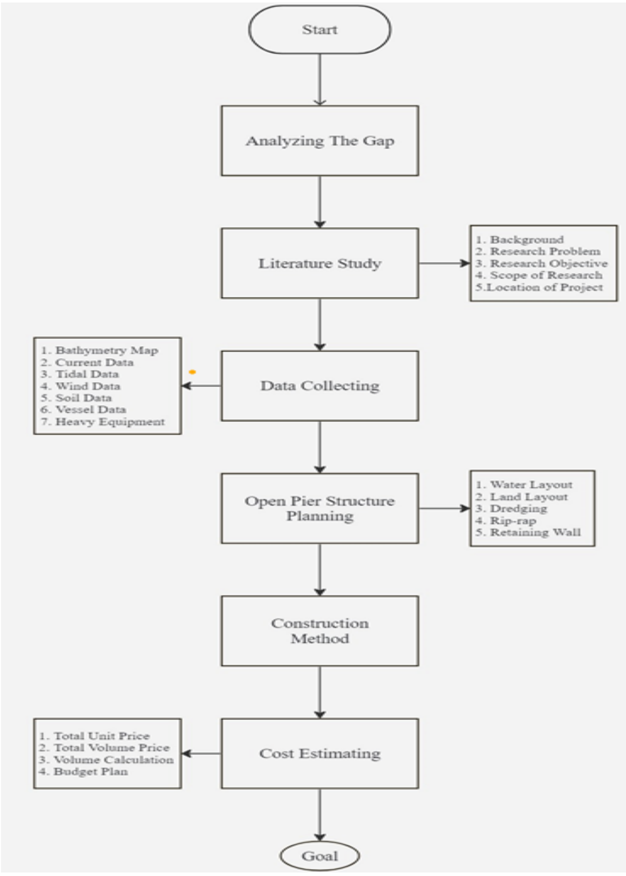

Figure 2. Flowchart.

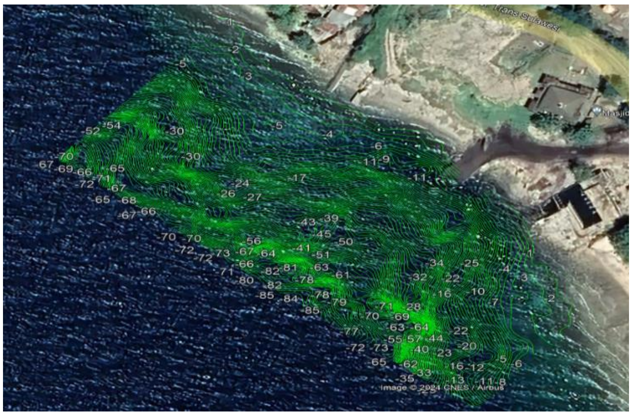
Figure 3. Bathymetry map.

3) Wind Data

Wind data can be seen on Table 2

4) Wave Data

Wave data obtained with several steps. Firstly, forecasting based on wind data and fetch effective, and the outcome is wave height each wind direction. Second, analysis with Weibull and Gumbel method in order to find wave height in 2, 5, 10, to 100 years return period. Last, from each data, we took the most critical value and R value close to 1, and then analyze with refraction considerations due to seabed elevation difference to gain wave height on the face of the jetty. Based wave analysis, the wave height taken is +1,76 mLWS.

5) Soil Data

Soil data used for this project based on 2 points of bore log. Named BL-1 and BL-2. SNI 1726:2020 is used for determining the classification of the soil. Soil data can be seen on Figure 4.

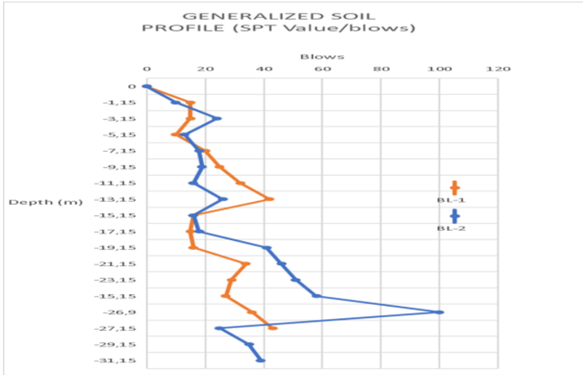

Figure 4. Soil data.


Figure 5. 10.000 DWT coal barge.

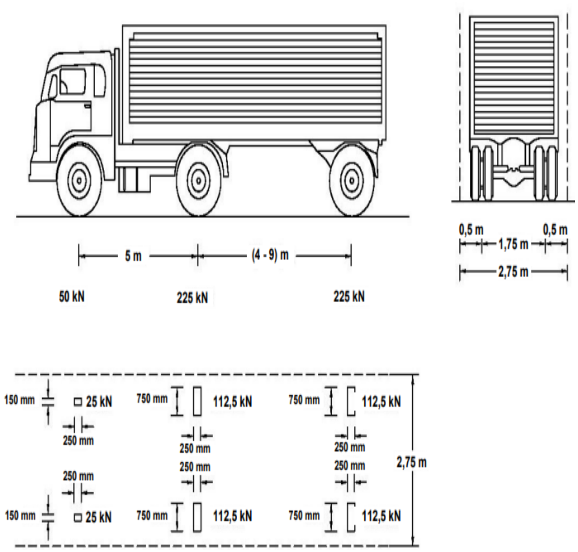

Figure 6. Dimension and loads of truck.

6) Vessel Data

The specification of the vessel is shown below:

a. Dead Weight Tonnage (DWT) = 10000 MT
b. Length of Overall (LOA) = 96,56 m
c. Breadth (Width) = 27,43 m
d. Draft = 4,88 m
e. Depth = 6,1 m

The designed vessel can be seen on Figure 5.

7) Unloading Equipment

The equipment used for unloading purposes is truck. The specification and dimension of the truck is based on SNI

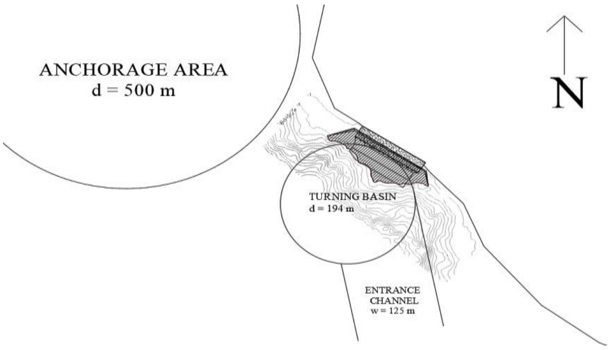

Figure 7. Water layout.

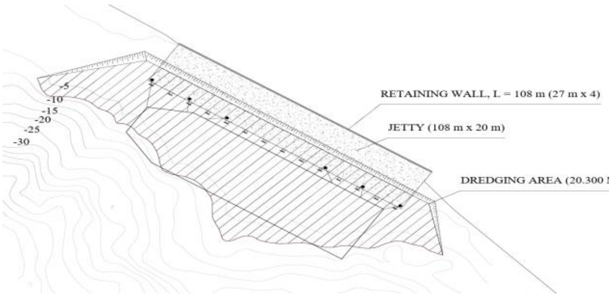

Figure 8. Land layout.

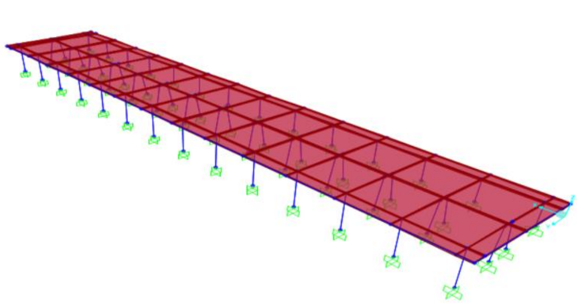

Figure 9. Jetty model in SAP2000.

1725:2015. The dimension and loads each axle can be seen on Figure 6.

III. RESULTS AND DISCUSSION

A. *Layout Evaluation*

Layout evaluations is needed for vessel can berth safely. Water layout determined, while land layout determined based on [2], [8-9].

1) *Water Layout*

The result of water layout including; entrance channel, turning basin, berth basin, and anchorage area can be seen on Figure 7.

2) *Land Layout*

After analyzed data, the jetty dimension is 108 x 20 m. The retaining wall needed is along the jetty's length. And for dredging, the area is 20.300 m^3. The selection of heavy equipment for dredging, suction cutter is the selected heavy equipment based on seabed and volume of dredging. Figure 8 is the illustration of the selected heavy equipment for dredging. The result of land layout including; the dimension of jetty, elevation of jetty, dredging volume, can be seen on Figure 8.

Table 1.
Tides Elevation

Water Level Condition	Symbol	Elevation (mLWS)
High Water Springs	HWS	+1,343
Mean Sea Level	MSL	+0,671
Low Water Springs	LWS	0,00

Table 2.
Wind Velocity at Molotabu, Gorontalo Recapitulation

Year	Wind Velocity (m/s)			
	West	Southeast	South	Southwest
2002	3,66	7,07	4,86	3,91
2003	4,84	6,92	4,47	4,09
2004	5,26	6,42	4,55	3,53
2005	3,97	6,54	4,46	4,11
2006	4,55	7,72	4,59	3,97
2007	4,60	7,33	4,56	4,69
2008	4,62	6,78	4,34	3,33
2009	4,50	7,52	4,77	3,55
2010	5,53	5,18	3,63	4,07
2011	4,70	6,91	3,96	4,18
2012	4,80	6,74	4,42	3,47
Max	5,53	7,90	5,33	5,04

Table 3.
Moment of Slab Recapitulation

Type	Position	Moment (kg.m)
A1	Mlx	10983,98
	Mtx	-11327,7
	Mly	13823,51
	Mty	-17049,97
A2	Mlx	780,48
	Mtx	-780,48
	Mly	780,48
	Mty	-780,48
A3	Mlx	1860,31
	Mtx	-2419,82
	Mly	760,8
	Mty	-6398,38

3) *Structure Planning*

Structure planning designed based on [3], [5], [7-13]. For reinforcement calculation, analyzed based on [8]. Structure planning including; structure modelling, slab planning, beam planning, pile cap planning, and foundation planning. The control that must be considered is the control of the crack width. To control crack width, Equation 1 below is used.

$$W = \alpha \left(C_3 \, x \, d + C_4 \frac{dp}{\omega p} \right) \left(\sigma_a - \frac{C_5}{\omega p} \right) 10^{-6}$$

4) *Structure Modelling*

Structure planning is started from modelling assisted by SAP2000 and the model can be seen on Figure 9.

5) *Slab Planning*

There are 3 different dimensions of slab that analyzed. The Table 3 is the moment recapitulation of each slab. Slab planning results such as reinforcement and crack control can be seen on Table 4.

6) *Beam Planning*

In this project, there are 2 type of beam. The difference is only on the beam's span, 8 m span and 2 m span. Table 5 is the recapitulation of beam's moment. Beam planning results

Table 4.
Flexural Reinforcement and Crack Control in Slab Recapitulation

Type	Length (mm)	Width (mm)	Thickness (mm)	Flexural Reinforcement				Crack Control
				Support X	Support Y	Field X	Field Y	
A1	8000	8000	350	D 22 - 125	D 22 - 90	D 22 - 125	D 22 - 100	OK
A2	8000	2000	350	D 16 - 125	D 16 - 125	D 16 - 200	D 16 - 200	OK
A3	2000	2000	350	D 16 - 200	D 16 - 125	D 16 - 200	D 16 - 200	OK

Table 5.
Moment of Beam Recapitulation

Type	Force	Moment (kN.m)
B1	Mtum	-557,69
	Mlap	717,91
B2	Mtum	-399,4
	Mlap	38,03
Plank Fender	Mtum	-1826,8
	Mlap	1826,8

Table 6.
Reinforcement Needed and Crack Control in Beam Recapitulation

Type	Length (mm)	Height (mm)	Width (mm)	Flexural Reinforcement		Shear Reinforcement		Crack Control
				Support	Field	Support	Field	
B1	8000	500	750	4 - D 40	6 - D 40	ø 13 - 200	ø 13 - 200	OK
B2	2000	500	750	6 - D 29	2 - D 29	ø 13 - 150	ø 13 - 150	OK
Plank Fender				D 36 - 100	D 36 - 100	ø 13 - 150	ø 13 - 150	OK

Table 7.
Moment of Pile Cap Recapitulation

Type	Position	Moment (kg.m)
Single Pile Cap	Mx	29242,51
	My	57997,49
Batter Pile Cap	Mx	87982,76
	My	91457,83

Table 8.
Flexural Reinforcement and Crack Control in Pile Cap Recapitulation

Type	Length (mm)	Width (mm)	Thickness (mm)	Flexural Reinforcement		Crack Control
				X-Direction	Y-Direction	
Single	2000	2000	1000	D 32 - 200	D 32 - 100	OK
Batter	3000	2000	1000	D 40 - 125	D 40 - 140	OK

Table 9.
Designed Pile Depth Recapitulation

Type	Force		Moment		Pile Depth (m)	Bearing Capacity	
	Push (ton)	Pull (ton)	Mx (ton.m)	My (ton.m)		Pull (kN)	Push (kN)
Single Pile (P1)	167,54	-	25,08	25,92	17	-	4925,78
Batter Pile	134,61	24,42	34,88	32,46	11 & 3	718,44	3531,57
Single Pile (P2)	139,17	-	54,83	35,3	15	-	4091,43

such as reinforcement and crack control can be seen on Table 6.

7) Pile Cap Planning

2 types of pile cap is planned in this project, for single pile and batter pile. Because the unloading process using truck, there are eccentricity need to be considered. Table 7 is moment recapitulation on pile cap. Pile cap planning results such as reinforcement and crack control seen on Table 8.

8) Foundation Planning

There are several control need to be analyzed including; bearing capacity analyzis, depth of pile (Table 9), strength of pile control (Table 10), and reinforcement of pile (Table 11). Strength of pile control equation is shown as equation (2)-(8) below.

a. Deflection Control

$$\delta occur < \delta allow$$

b. Moment Control

$$Mux, Muy < Mcrack$$

c. Axial Control

$$F_e = \frac{\pi^2 E}{\left(\frac{KL}{r}\right)^2}$$

d. Axial – Moment Interaction Control

$$\frac{P_U}{P_n} + \frac{8}{9}\left(\frac{M_{ux}}{M_{cx}} + \frac{M_{uy}}{M_{cx}}\right) \leq 1$$

e. Tension Control

$$\sigma < \sigma_{allow}$$

f. Shear Control

$$V_u < 0{,}75\, V_n$$

g. The Ability of The Pile to Stand Alone

Table 10.
Strength of Pile Control Recapitulation

Remark	Jetty		
	Existing	Allowable	Status
Deflection Control (mm)	14,9	25	OK
Moment Control (ton.m)	25,92	86,13	OK
Axial-Moment Interaction Control (ton)	167,54	483,9	OK
Shear Control (ton)	6,68	403,25	OK
Tension Control (Mpa)	74,61	284	OK
The Ability of The Pile to Stand Alone (s)	0,36	3,15	OK

Table 11.
Reinforcement Needed in Pile Recapitulation

Type	Distribution Reinforcement		Spiral Reinforcement	Concrete Casting Depth	Base Plate	
	Amount	Length (mm)	Amount	Length (mm)	Thickness (mm)	Anchor
Single	7 D - 32	640	ø 12 - 75	To – 1 mLWS	10	3 - ø 22
Batter	5 D - 32	640	ø 12 - 75	To – 1 mLWS	10	3 - ø 22

Table 12.
Forces on Retaining Wall Recapitulation

Position	Forces	Unit
Breast Wall	H	2591,54 kN
	M	-190,67 kN.m
Foot	H	3239,54 Kn
	M	70,68 Kn.m
Cantilever	H	526,38 kN
	M	-55,08 kN.m
Stiffener	H	185,08 kN
	M	118,46 kN.m

Table 13.
Retaining Wall Reinforcement Recapitulation

Section	Flexural Reinforcement	Shear Reinforcement	Crack Width (mm)
Breast Wall	D25-100	D13-150	-0,041
Foot	D19-200	D13-120	-0,716
Cantilever	D32-150	D13-170	0,006
Stiffener	D22-100	D16-120	-0,013

Table 14.
Rip – Rap Dimension Recapitulation

Layer	Type	W (ton)	Thickness (m)
Primary	Rock	1,5	1,7
Secondary	Rock	0,15	2

$$\omega_t = 1{,}73 \sqrt{\frac{EI}{\frac{wl^2}{g}}} > \omega$$

9) Retaining Wall Planning

There are 4 sections of retaining wall (breast wall, foot, cantilever, and stiffener). Reinforcement planning of retaining wall was calculated same as slab reinforcement planning.

Table 12 is recapitulation of forces on retaining wall. Retaining wall reinforcement recapitulation can be seen on Table 13.

10) Rip – Rap Planning

To retain the soil behind the jetty structure, a rip-rap structure is required. The structure is divided into 2 layers, primary and secondary.

Rip – rap planning is based on [1]. To control rip-rap stability, the Geo5 application is used to assist stability control. Table 14 is the dimensions of rip – rap. Rip – rap stability control can be seen on Table 15.

B. Construction Method

The construction implementation method of open pier jetty Molotabu, Gorontalo, as follow:

1) Preparation work

Including permission, land clearing, and keet director.

2) Lower Structure

Before upper structure work, lower structure needs to be done first. Lower structure work including; dredging, rip-rap work, retaining wall work, and pile installation.

3) Upper Structure

Upper structure works are pile cap work, beam work, and slab work.

4) Fender and Bollard Installation

And the last one is jetty’s facilities installation, there are fender and bollard installation.

C. Cost Estimating

In determining price of wages, materials, and equipment, the price chosen is from *Peraturan Menteri Perhubungan No.*

Table 15.
Rip – Rap Control Recapitulation

Method	FS	FS min	Status
Bishop	2,54	1,5	OK
Fellenius/Peterson	2,21	1,5	OK
Spencer	2,53	1,5	OK
Janbu	2,53	1,5	OK
Morgenstern-Prince	2,53	1,5	OK

Table 16.
Cost Estimating Recapitulation

Cost Recapitulation			
No	Work Breakdown	Work Price	
1	Preparation Work	Rp	106.200.000
2	Upper Structure Work	Rp	3.569.646.300
3	Lower Structure Work	Rp	43.896.009.492
4	Jetty Facilities Work	Rp	3.752.401.017
Total		Rp	51.324.256.809

Table 17.
Layout Evaluation Results

Location	Information	Result	
		Dimension	Unit
Entrance Channel	Depth	6,5	-mLWS
	Width	125	m
Turning Basin	Depth	6,5	-mLWS
	Diameter	194	m
Berth Basin	Depth	6,5	-mLWS
	Length	108	m
	Width	50	m
Anchorage Area	Radius	250	m
Jetty Dimension	Length	108	m
	Width	20	m
	Elevation	3,5	+mLWS
Dredging	Volume	20.300	m^3
Rip-rap	Height	3,7	m

78 Tahun 2014 was adjusted to prices in Gorontalo by multiplying by the expensiveness index value in Gorontalo. The recapitulation of cost estimating for open pier jetty Molotabu, Gorontalo, can be seen on Table 16.

IV. CONCLUSION

Based on analyzis and evaluation that have been carried out, the conclusion is as follow; (1) The result of water and land layout can be seen on Table 17; (2) The result of jetty's structure can be seen on Table 18 and Table 19; (3) Construction implementation method of this project started from dredging, rip-rap work, retaining wall work, and ended with jetty's structure work; (4) Estimated cost for this project is Rp 51.324.256.809,00 (*Fifty-one billion three hundred twenty-four million two hundred fifty-six thousand eight hundred and nine rupiah*)

Table 18.
Rip – Rap Dimension Recapitulation

Layer	Type	W (ton)	Thickness (m)
Primary	Rock	1,5	1,7
Secondary	Rock	0,15	2

Table 19.
Structure Planning Result

Retaining Wall						
Retaining Wall Length	27	m	x	4		
Breast Wall Dimension	40	x	200	cm		
Foot Dimension	250	x	40	cm		
Cantilever Dimension	15	x	35	cm		
Stiffener Dimension	30	x	177	cm		
Concrete Quality	f'c	35				
Concrete Cover	6			cm		
Reinforcement Quality	BJTP	280	&	BJTS	280	
Breast Wall Reinforcement	D	25				
Shear Reinforcement	ø	13	ø			
Jetty						
Structure Dimension	108	x	20	m		
Crown Height	+2,5			m LWS		
Concrete Cover	6			cm		
Slab Thickness	35			cm		
Beam Dimension	75	x	50	cm		
Single Pile Cap	200	x	200	x	100	cm
Batter Pile Cap	300	x	200	x	100	cm
Concrete Quality	f'c	35				
Steel Pile Quality	SKK	490				
Reinforcement Quality	BJTP	280	&	BJTS	280	
Slab Reinforcement	D	22	&	D	16	
Flexural Reinforcement	D	19	&	D	32	
Shear Reinforcement	ø	22				
Pile	SPP	ø600				
Pile Depth	-3	s/d	-17	m LAT		
Fender	SCN 1000 F2.7 + Frontal Pad 3,8 x 2 m					
Bollard	Pillar Bollard 50 T					

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