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Analysis of the Trestle Foundation on Ships Docked in Crude Palm Oil (C.P.O.) Kabil Port Batam City, Indonesia.

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ABSTRACT

Batam Free Trade Zone (B.P. Batam) had established the first stage liquid bulk carrier port since 1987. In the beginning, that capacities transfer started from 70mt/hour to 150 mt/hour. Currently, it has developed the second stage plan within flow rate 300 mt/hour to 400 mt/hour. Port services consist of loading and unloading passengers, liquid, gas, and solid goods following PM 53 of 2018. The purpose of this study is to determine whether the depth of the trestle foundation is sufficient for the standards and requirements for ships berthed at the Port. The method used in this research is the quantitative approach. Data analysis was carried out by observation, interview, documentation, and investigation. The research period starts from early October 2020 to March 2021. In brief, the research results have shown that the depth of structure foundation trestle is safely constructed, adequate strength impact by respectively horizontal and vertical load factor for the vessel 35000 DWT berthing to jetty at Kabil Batam City.

Keywords: Foundation Trestle, Crude Palm Oil (C.P.O.), Berthing.

1. INTRODUCTION

Indonesia has around 560 ports from the smaller Port to the more critical Port in 34vinces on Indonesia's various islands function of ports to connect the between regions, cities throughout the remote island for the efficient movement infrastructure and facilities. Source: Indonesian Ports as Contributors to State Foreign Exchange in a Business Law Perspective (Gultom, 2017).

Batam City consconsists25 ports of Domestic and Internasional Ports designated as passengers and cargo services starting from Sambu Port, Sekupang Port from sector 1 to 6, Batu Ampar Port, Macgobar Port, and K.I.M, Batu Ampar, K.I.M. Port Kabil, Sarana Citra Nusa Kabil Port, and Batam Center Port, Roro Port and C.P.O. Kabil Port. Those ports had served for domestic and IInternationalflags. The scope of ports services consists of embarking and disembark passe, and cargo Argos included liquid, gas, and finished following with government regulation PM 53 for 2018 (Statistik, Badan Pusat Riau, 2019).

Research on crude palm oil (C.P.O.) planning has previously been discussed by (Herwanda et al., 2020) analysis of a single pile's carrying capacity the experiment loading test, sondir, and examinations using the Plaxis 8.2 program, the carrying capacity is taken for the smallest pile. Furthermore (Prastio, 2019) trestle floor plate structure designed by the planner on the Curah Kabil Wharf Development and Development project can support these structural loads and live loads that will occur when the dock operates. Moreover, (Statourenda, 2020) Jetty Crude Palm Oil (Cpo) Planning Precast in Tanjung Pakis Waters Lamongan, Jawa Timur by evaluating the dock layout, planning the detailed structure of the jetty crude palm oil, determine and compile the Method of implementation effective, and perform the calculation of the budget plan (R.A.B.) required.

The main operation of the Sambu port is to transfer and discharge high-speed diesel oil, Bio Diesel, Marine Fuel Oil 180. Batu Ampar Port serves as loading and unloading container cargo, Sekupang K.I.M. Port (hinterland) from sector 1 to 6. Batam Center Port services, Sekupang Terminal, Harbor bay Terminal, Nongsa are the ferry terminal for domestic and international. International providing as transport at vehicles through Sekupang Port Punggur Port.C.P.O.'ss Kabil has served the large transportation of Cothran household as the global location is quite strategic due to nearby the nearby Strait on the international at is the reason how important the Port in Batam city. This research would like to find out the root cause of how foundation trestle's and vessel berthing's are safely constructed, adequate strength impact by respectively horizontal and vertical load factor for the vessel 35000 DWT berthing to jetty at Kabil Batam city. Their ore," "Analysis Structure of Foundation Trestle Designing for the Vessel Berthing at C.P.O. Kabil Port Batam City, Indonesia."

Based on the data, there was volume output of the cargo load and unloaded in Batam city as follow:

Table 1. Load and Unload Volume Cargo (ton)

Years	Domestic		Internasional	
	Unload	Load	Import	Export
1994	110,987	49,345	236,561	229,355
1995	119,174	73,335	251,803	270,164
1996	141,021	68,549	301,176	245,255
1997	136,050	75,403	336,576	271,230
1998	109,524	50,123	227,770	277,151
1999	132,063	59,982	261,770	335,235
2000	159,466	93,263	319,039	391,664
2001	184,866	56,026	326,156	379,198
2002	199,901	123,058	345,382	451,118
2003	216,158	270,292	375,471	454,118
2004	373,149	53,235	375,135	292,510
2005	320,372	92,843	360,222	201,854

Source: Discharge and Loading K.M. No 62 for the year 2006

Table 2. Load and Unload Volume Liquid Bulk Cargo (ton)

Vessel	Volume Load and Unload in 2030		Nos of Vessel Arrival in 2030	Max DWT in 2030
	Vol	Unit		
Container	16,000,000	TEU's	236,561	229,355
General Cargo	2,116,859	Ton	251,803	270,164
Liquid Bulk	7,200,000	Ton	301,176	245,255
Passenger	2,449,109	Pax	336,576	271,230
Internasional Flag	-	50,123	227,770	277,151

Source: Discharge and Loading K.M. No 62 for the year 2006

The factual data were volume loading and unloading cargo. It had shown that the most volume cargo is unloaded 320,372m³ & loaded 92,834m³ for domestic and 360,222m³ & 454,441 for the international, but started not much as before year. To require per year by deadweight tonnage (DWT) vessel from 10,000 ton to 35,000 ton. Every ship should have considered the new construction design vessel development and innovation by naval architectures in the past 20 years (*Peraturan Menteri Perhubungan No. K.M. 62 Tahun 2006*, 2006).

Whereas Kabil C.P.O. port had demanded bunkering capacity within 300-400 ton/hour by the current operation. Due to the increasing number of vessels alongside and standby at anchorage area. The foundation trestle should be rigidly designed for each ship's berthing. How strength foundation design for allowable bearing capacity, why it does not collapse in case of energy berthing to the cone fender & bulkhead sidewall.

2. LITERATURE REVIEW

2.1 Design of Structural Port

There are three kinds of ports: wharf, pier, and jetty construction in the Port. Berth structural surface plan can be optional by using open type or closed type of the structural. Pen piles quay/wharf, bulkhead wall, concrete bulkhead wall gravity retaining structure, and reinforced concrete caisson (Triadmodjo, 2009).

Deck piles mean a combination of piles constructed as one deck. All the deck loaded, including vessel berthing and mooring force received by the pile and deck structure. The bulkhead wall is a part vertical land-backed retaining wall tied back to the dead anchor system. The crane rail & pedestal connect to the wall vertical loads. The concrete bulkhead wall gravity retaining structure is also depending on self-weight stability. This can be formed by steel sheet pile, mass concrete blockwork. Then reinforce concrete caisson is filled in by rock completed by base slab & cope the vertical support fenders dan bollards (Asiyanto, 2008).

Some types of foundation trestle of concrete shape piles are made from such as: rectangular shape (RC) or Spun (SP). Those have allowable bearing capacity obtained from Boring Data. It could be computed by using equation (Tomlinson & Woodward, 2014) as follow:

$$Q = Q_b + Q_s$$

$$Q = A_b . q_b + A_s . f_s \text{ total}$$

$$Q_{all} = Q / S_f$$

In which :

Q : Ultimate Bearing Capacity (ton)

Qall : Allowable Bearing Capacity

qb : Unit End Resistance

(1) Cohesive Soil $q = 9c$

(2) Granular Soil $q = p_o N_q$

30 Nd limit (max 1500 t/m²)

C : Undrained Shear Strength (Cohesion) (t/m²)

Ab : Cross Section area of Pile (m²)

D : Diameter of Pile (m)

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As	: Surface area of Pile	(m)
Fs total	: Unit skin Friction	
	(1) Cohesive Soil $fs = \alpha C$	
	(2) Granular Soil $fs = Kpo \tan\Phi = N/5$	
α	: Adhesion Factor	
Nd	: Average N Value D Below Foundation tip and 8D above Foundation tip	
Φ	: Friction Angle Between Pile and Soil	(°)
SF	: Safety factor	

The safety factor is approximately 2.5 - 3 allowable bearing capacity for the bottom of the depth foundation. It is for assuming the unexpected soil structural factor changing, for instance,e soil nonhomogeneous.

$$SF = qun/qn = (qu-\gamma Df)/(q-\gamma Df)$$

In which:

γ	: Weight Soil Volume on the Bottom Foundation
Df	: Depth foundation
qu	: Ultimate Bearing Capacity
q	: Total Pressure on the Foundation $q=P/A$

Allowable Bearing Capacity is also computed shallow foundation using by J.E Bowles: as follow

$$qult = c.Nc.sc + Po.Nq + 0.5\gamma BN\gamma Sr\gamma$$

$$Qall = qult/SF$$

In which:

Qall	: Allowable bearing capacity of shallow foundation	(t/m^2)
qult	: Ultimate bearing capacity of shallow foundation	(t/m^2)
c	: Cohesion	(t/m^2)
Po	: Overburden effective pressure	(t/m^2)
N c, N qγ	: The bearing capacity factor and width of the foundation.	
B	: Width foundation	
Sc & Sr	: Shape factor that depan on foundation effective shape	
ɣ	: Unit weighs of soil below the foundation	

$$Qall = (N/4).\ K \qquad B<4ft$$

$$Qall = (N/6).(((B+1))/B^2)^2/K \qquad B>4ft$$

$$K = 1+0.033.(D/B)$$

2.2 Principles of Vessel Berthing

The general-purpose pose tire fender is to absorb energy and impact force from the vessel berthing in orto not damage l a structural Port. The factor should be considered while choosing three fenders: sea wave, sea current, wind, vessel's dimensions and direction, availability of tugboat, type of Port l a, of captain (K captains, 2002). In which its vessel characteristic may classify by:

Table 3. Vessel Characteristic

Vessel Type	DWT (T)	D.T. (T)	L.O.A. (m)	P.P. (m)	Breadth (m)	Depth (m)	Max Draft (m)
Bulk Carrier	5,000	6,740	106	99	15.0	8.4	6.1
	7,000	9,270	116	108	16.6	9.3	6.7
	10,000	13,000	129	120	18.5	10.4	7.5
	15,000	19,100	145	135	21	11.7	8.4
	20,000	25,000	157	148	23	12.8	9.2
	30,000	36,700	176	167	26.1	14.4	10.3
	50,000	59,600	204	194	32.3	16.8	12.0
	70,000	81,900	224	215	32.3	18.6	13.3
	100,000	115,000	248	293	37.9	20.7	14.8
	150,000	168,000	279	270	43	23.3	16.7
	200,000	221,000	303	294	47	25.4	18.2
	250,000	237,000	322	314	50.4	27.2	19.4

Source: Comparative Study of Design Berthing Energy on Fender as per Indian Standard IS4651 Part-3:1974 and British Standard BS6349 Part-4:1994

The energy on the vessel generated a load force (F). so, in the design vessel, often assume the ship in the displacement tonnage. However, the ship's speed was estimated to be incorrect because of the ocean currents and the ship's speed. As science speed vessels were between 0.15 second to 1.0 second around 3.5 knot/10°deg to surface port sidewall. Energy berthing is used equation:

$$Ekin = Eship\,.\,f$$

The equation is being used as per India IS4651 part-3[2]

$$E_{kin} = \frac{Wd\,v^2}{2.g}\,.\,C_m.\,C_e.\,C_s$$

The equation is being used as per British BS6349 part-4[4]

$$E_{kin} = \frac{1}{2}.\,m.\,v^2.\,C_m.\,C_s.\,C_c.\,C_\epsilon$$

In which:

Ekin		= Energy Kinetic
M		= Mass Vessel
v		= Total displacement from acceleration in the centre to first touch
Cm		= Virtual dynamic mass coefficient [-]
Cs		= Softness coefficient
Cc		= Struktur waterfront Factor
Ce		= Berth configuration factor

B = Beam of vessel
C = Positive clearance between hull of vessel and face of cope
Cab = Abnormal impact factor
Cb = Block coefficient of the vessel's hull
D = Draught of ship
D = Diameter of Fender
E = Effective kinetic energy of berthing vessel

The below performance is representing the parameter of the difficulty and unfavorable breathing vessel. This curve refers to a recommended maritime work (R.O.M.), subject to a 30 & 50-year period.

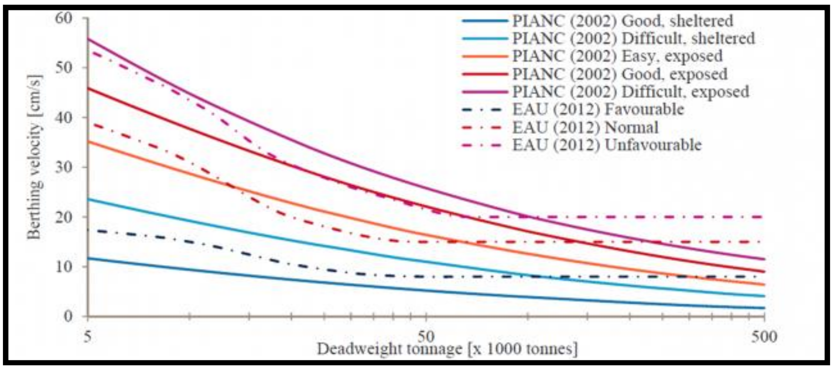

Figure 1 Berthing Velocity Curve PIANC 2002 and E.U.A. 2011

3. METHODOLOGY

This method of research to be used in the method literature and the Method quantitative to describe how the depth structural foundation trestle can absorb energy from the vessel. The data were collected the primary data B.P. Batam and the secondary data were collected from the documentation. The instrument is being carried out by observation, interview, documentation, and investigation. Using Method of framework research; as

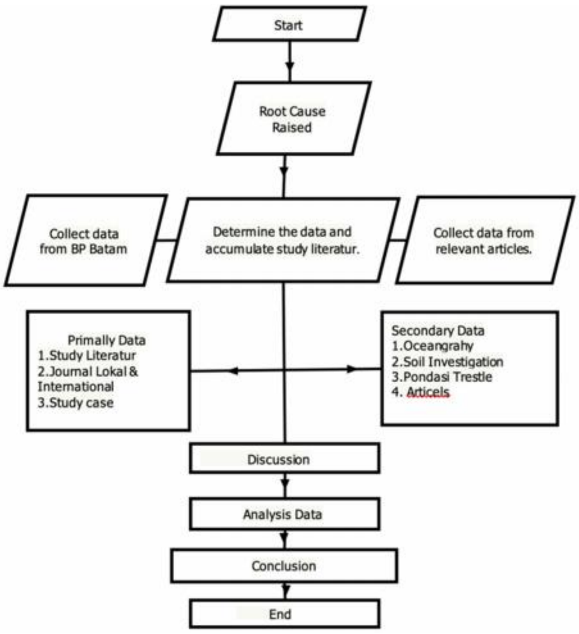

Figure 2 Research Framework

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The following project specification obtained from consultant B.P. Batam; as

Table 4. Project Specification of Port C.P.O. Kabil

Item	Description
Name of Project	: Development D.E.D. Port for Berthing at CPO KABIL
Location	: Kabil, Kecamatan Nongsa, Kota Batam, Kepulauan Riau 29467
Maximum wave	: 2-3 meter max/year
Density concrete	: 2,4 t/m³
Type of Port	: Pier
Type of foundation	: Trestle
Length of Port	: 273.6meter
Width of Port	: 33 meter
Mutu Beton Girder	: K-500
Concrete Compressive strength	: 415000 kpa ~ 415 MPA
The shape of the foundation trestle	: Spun Pile
Dimension	: Dia 609.6mm. 8-25, 13D-150, Pipe thickness19mm
Detail Cone Fender (*Fender*)	:UHMW-PEPAD 1300mm*3300mm*40 mm
	: OD*96mm & ID*600mm

Source: B.P. Batam

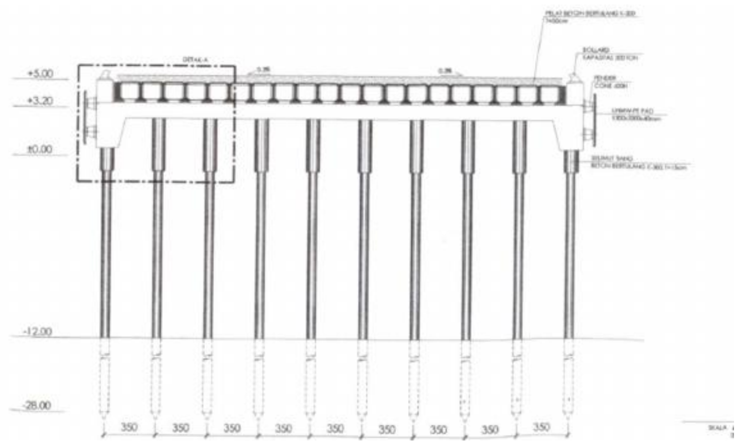

Figure 3 Front View of Pile Foundation Trestle source by B.P. Batam

The research location is located C.P.O. Port in Kabil, Nongsa District, Batam City, Riau Islands 29467 from 11 Nov 2020 to 11 Jan 2021, precisely coordinates universal transverse Mercator (UTM) at 01°04'1477" "N and 104°08'346"EE and the ship anchorage position are 1°9'45" 'N for big vessels in1'5'00"NN and104'9'00EE in the Riau Strait. The Local coordinate was performed Borehole Investigation soil test located at; as

Table 5. Borehole Investigation Soil

Bore Hole	Depth	X (m)	Y (m)	Z (m)
BH 1	16.18	403805.8	118917.4	+2.326
BH 2	14.45	403826.5	118926.5	-1.803
BH 3	20.34	403879.8	118887.9	-4.223
BH 4	20.02	403972.9	118872.7	-3.84
BH 5	18.02	403972.9	118872.7	-4.246
BH 6	10.18	404077.4	118962.9	-3.685
BH 7	20.05	404085.4	118872.7	-3.666
BH 8	24.08	404085.4	118844.7	-0.594
BH 9	21.00	404176	118807.4	-5.95
BH 10	20.45	404180	118844.7	-5.331
BH 11	20.02	404180	118872.7	-4.704
BH 12	9.00	403961.4	118784.8	-1.145
BH 13	14.15	403961.4	118692.2	-1.547

Source: Soil Investigation Report P.T. Pratama Widya (Borehole Investigation Soil of Table 5)

From the results obtained, Primary and Secondary data from B.P. Batam and related third parties. Researchers mostly use closed interviews and unstructured interview forms to investigate. So the C.P.O. Kabil Port is suitable to build the Port for specification; as

Table 6. Port Design for Vessel Alongside

Port characteristic	Max Vessel Design DWT		Ket
Deadweight tonnage	35000	ton	
Length	273.6	m	
Width	33	m	
Depth	-12	mdpl	

Source: B.P. Batam

4. RESULTS AND DISCUSSION

Based on primary and secondary data provided, we are computing the total friction foundation trestle of and As variety depth piling has been carried out from onsite according to method computing by M.J Tomlinson.

Table 7. Bore Hole No#1

Depth (M)		L	C	a	a	f	f	Unit
2	3.5	1.5	0.5	0.96	0.72	0.72	0.54	t/"
3.5	6.0	2.5	0.75	0.75	0.72	1.40625	1.35	t/"
6.0	10.0	4	2	0.33	0.248	2.64	1.984	t/"
10	12	2	2	0.33	0.248	1.32	0.992	t/"
10	13	3	2	0	0.248	0	1.488	t/"
Grand (Tfs)total fs*075 Spun/Bored pile						6.08625	6.354	t/"
						5	5	t/"

Source: Data Analysis, 2021

Tabel 8. Bore Hole No#2

Depth (M)		L	C	a1	a2	fs1	fs2	Unit
2.0	4.0	2	0.75	0.75	0.563	1.125	0.8445	t/"
4.0	8.0	4	2	0.33	0	2.64	0	t/"
4.0	9.0	5	2	0	0.248	0	2.48	t/"
Grand (Tfs)total fs*075 Spun/Bored pile						3.765	3.3245	t/"
						3	2	t/"

Source: Data Analysis, 2021

Followed by computing the allowable bearing capacity for the compression pile;

Table 9 Allowable Bearing Capacity

Location	Spun Pile	Size Dia (mm)	Ab (m^2)	Qb (0.75/1*50*30)	As (3.14*)	Tsf	Qs/ton (Tsf*As)	Qall/ (t/m') (Qb+Qs)
Bh1	12	600	0.2826	317.925	1.884	5	9.420	130.938
Bh2	8	600	0.2826	317.925	1.884	3	5.652	129.4308
Bh3	10	600	0.2826	317.925	1.884	4	7.536	130.1844
Bh4	6	600	0.2826	317.925	1.884	22	41.448	143.7492
Bh5	8	600	0.2826	317.925	1.884	43	81.012	159.5748
Bh6	4	600	0.2826	423.9	1.884	14	26.376	180.1104
Bh7	12	600	0.2826	423.9	1.884	18	33.912	183.1248
Bh8	12	600	0.2826	423.9	1.884	85	160.14	233.616
Bh9	10	600	0.2826	317.925	1.884	6	11.304	131.6916
Bh10	23	600	0.2826	423.9	1.884	50	94.2	207.24
Bh11	10	600	0.2826	317.925	1.884	59	111.156	171.6324
Bh12	6	600	0.2826	317.925	1.884	6	11.304	131.6916
Bh13	8	600	0.2826	317.925	1.884	16	30.144	139.2276

Source: Data Analysis, 2021

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Energy berthing simulated by vessel her named MV. ATLANTIC MAZATLAN and complete with pier and dimension fender UHMW-PEPAD 1300mm*3300mm*40 mm OD*96mm & ID*600mm.

Name of Vessel M.V ATLANTIC MAZATLAN

Type of Vessel BULK CARRIER

Register SINGAPORE

Call sign S6AGA3

Dimension L.O.A:189.80 m, LBP 181 m, BM 32.26m,
DM=16.90m

Table 10. Ship Particular

Certs of Tonnage	Internasional (T)	Panama Canal (T)	Suez Canal (T)
Gross Reg Tonnage	27986	26322	28850
Net Reg Tonnage	17077	23253	27986
Displacement	59468	58136	56508
Deadweight	51628	50296	48966
Draft	12.173	11.925	11677
TCP	53.6	53.5	53.4
Freeboard	4.77	5.018	5.266

Souce:https://www.gob.mx/cms/uploads/attachment/file/161550/Atlantic_Mazatlan.pdf

The Above ship particular can calculate the impact berthing energy from vessel DWT 51692-ton bulk carrier; as

Eccentricity Coefficient $(C\ )$

$$C\ = \frac{K^2 R^2 C\ \ {}^2 y}{K^2 + R^2}$$

$$C\ = \frac{6\ ,5^2.5\ {}^2C\ \ (5\ {}^2)}{6\ .5^2+5\ {}^2} = 0,974150012$$

Block Coefficient $(C\ )$

$$C\ = \frac{M}{L.B.D.W}$$

$$C\ = \frac{59468}{181.32,26.45,4.1,03} = 0,2177947051$$

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Virtual Mass Factor $(C\quad)$

$$C \quad = 1 + \frac{\frac{3,1}{4}.D^2.L.W}{D} > 20000T$$

$$C \quad = 1 + \frac{\frac{3,1}{4}.1\ ,6\ ^2.1\quad ,6\ .1,0}{5} = 1,08041$$

L.P.P. = Length of Perpendicular Vessel

$0,852\ x\ 189.80^{1.0}$ =179.69m

K = Radius of Gyration

$$(0.19.c\ \ .0.11).L$$

$$K = (0,19 + 0,21.0,11)179,69 = 38,446008336$$

Normal Berthing Energy

$$E \quad = \frac{W\quad .V^2}{2.g}.C\quad .C\ .C$$

$$Enormal = \frac{51,628.0.14^2}{2.9,81}.1,08041.\,0,974150012\,.\,0,95 = 51.56t/m^2$$

Safety Factor According to British Standard *(2)

$$51,56t\,.\,2 = 103t/m^2$$

Energy Abnormal Berthing

$$E_{ai} \quad = C_a\ .\ E_n$$

$$E_{abnormal=}0,21779.\,51.56 = 11,2292t/m^2$$

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Table 11. Recapitulation Data

Description	Syb	Value	
L.O.A.	L	189.8	M
Breath	B	32.26	M
Depth	D	16.9	M
Displacement	DW	59,468	M(t)
Dead Weight	BV	51,628	M(t)
Berthing Velocity	v	0.1	(m/s)
Water Density	ρ	1.03	t/m³
Virtual Mass Factor	Cm	1.08	Cm
Block Coefficient	Cb	0.2178	Cb
Radius of Gyration	K (m)	38.7	K(m)
Distance from bow to impact point	X (m)	75	X(m)
Distance from the point off contact center of mass.	R	55	R(m)
The angle between the velocity vector and the line between the point of contact and the center of mass	Φ	45.5	Φ (°)
Eccentricity Coefficient	Ce	0,974150012	Ce
Berth Configuration Coefficient	Cc	1	Cc
Softness Coefficient	Cs	0.95	Cs
Result			
Normal Berthing Energy Ed	En	51,56	t/m³
Abnormal Berthing Factor	Cab	1	Cab
Abnormal Berthing Energy	EAB	11,2292	t/m³

Source: Data Analysis, 2021

5. CONCLUSIONS

The above results are shown that the construction foundation trestle had built in the condition that possesses result compression strength bearing capacity is adequate compress pile from B.H. 1 to 13. Therefore, the foundation trestle may not simply collapse due to general shear failure and local shear failure. Also, normal energy berthing and abnormal berth yield are still capable of absorbing by UHMW-PEPAD Fender. Subject to be changing the velocity vessel or unfavorable weather condition has happened. This may seriously cause property damage to either the Port or the ship.

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