MMP Mitra Murni Perkasa	BED & DED JETTY MMP NICKEL SMELTER PROJECT	PT WIJAYA KARYA (Persero) Tbk
MMP-CAL-100-C-0002	CALCULATION FOR TRESTLE	Rev. No : 1 Page : 1 / 47

MMP Mitra Murni Perkasa
BASIC ENGINEERING DESIGN

ORIGINAL

WIKA	FOR APPROVAL	
	DATE	18 Apr 2022

PROJECT NAME : **BED & DED JETTY MMP NICKEL SMELTER PROJECT**

CLIENT : **PT. MITRA MURNI PERKASA**

CONTRACTOR : **PT. WIJAYA KARYA (Persero) Tbk**

PROJECT LOCATION : **TELUK WARU, BALIKPAPAN – KALIMANTAN TIMUR**

CONTRACT NO. : **065-1/LGL/MMP-WIKA/XII/2021**

MMP001 – MMP Nickel Smelter Project Document Review Code Stamp		MMP
Code	Description	
C1	Approved	
C2	Approved with comments Work may proceed	✓
C3	Revise and resubmit Work may not proceed	
C4	Not Reviewed No review required / Information only	
Date	Reviewed By	Signature
	YO	

1	16-Apr-22	Re-Issued for Approval	DD	HS	DP/MAR	DW	DH
0	1-Mar-22	Issued for Approval	DD	HS	DP/MAR	EH/FA	DH
Rev.	**Date**	**Description**	**PT.ATRYA**	**PT.WIKA**	**PT.ATRYA**	**PT.WIKA**	**PT.WIKA**
			Prepare		**Checked**		**Approved**

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ENGINEERING CONSULTANTS

REVISION SHEET DESCRIPTION

NO	PAGE	SUBJECT	DESCRIPTION OF CHANGE

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1 INTRODUCTION

1.1 Project Definitions

In this document, the following words and term shall have the meanings here by assigned to them, unless noted otherwise.

OWNER	: PT. MITRA MURNI PERKASA
CONTRACTOR	: PT. WIJAYA KARYA (Persero), TBK
VENDOR	: The supplier (Manufacture or Distributor) of equipment purchased by CONTRACTOR
OTHERS	: The party which have been contracted by COMPANY to supply equipment, service or material

1.2 Project Location

Project location is at Kariangau, West of Balikpapan, about 27 km from Balikpapan City. The distance from Balikpapan City to site is about 28 km by road.

Figure 1.1 Project Location

Figure 1.2 Enlarged Project Location

1.3 Propose of The Document

This document presents basic design and calculation for the trestle structure, which is part of jetty facilities at Jetty MMP Nickel Smelter Project at Kariangau, Balikpapan, East Kalimantan, Indonesia. A specific design basis have been developed and considered in the calculations for the design.

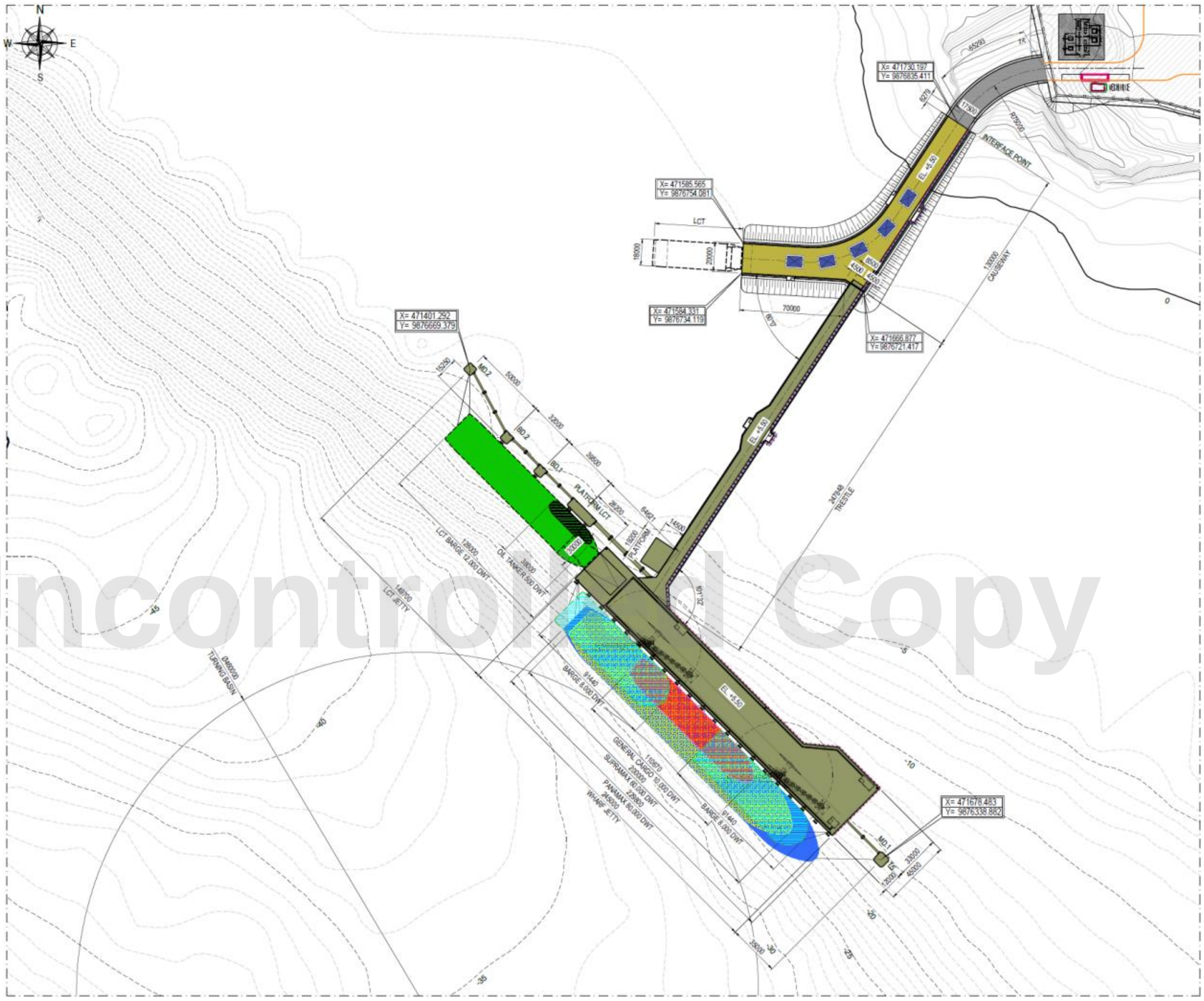


Figure 1.3 General Layout of Jetty MMP Nickel Smelter

1.4 Structure Description

Access way from land to loading/ unloading jetty area is required as an access from shore/ inland area. In this project, access way that connects the causeway to the jetty area is called a trestle. Trestle structure and will accommodate the system of pipelines and cable tray. In addition, trestle structure will be provided with guardrail, lighting, drainage, and sedimen tanks in two locations.

Trestle will be divided into two lanes, one lane for roadway with 8.0 m of width and the other lane is for pipeline and cable tray with 1.5 m of width The roadway should be designed for truck, mobile crane in empty load, and other material handling vehicle/ equipment. Total length of trestle 248 m with 11.25 m of total width. In the roadway, one location is provided with a roadway widening to 12 m which functions as an emergency area/ lane. Deck elevation should be at +5.50 mCDL.

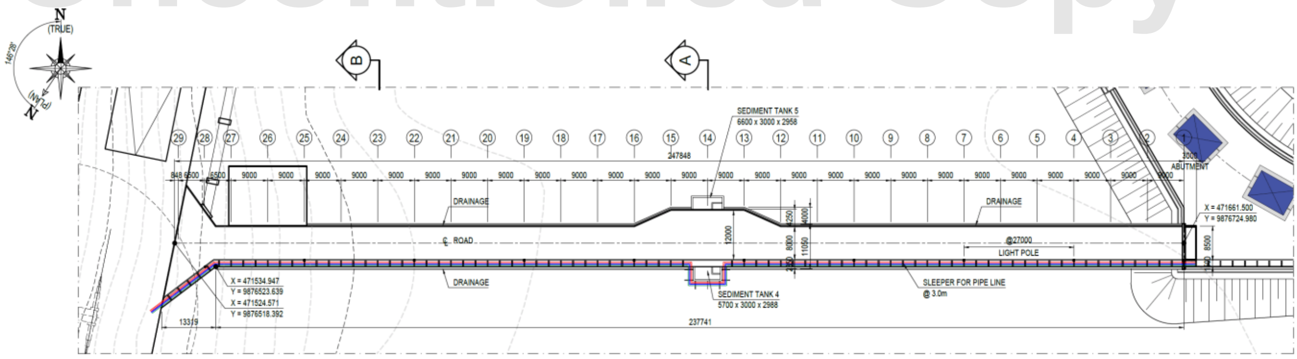


Figure 1.4 Layout of Trestle

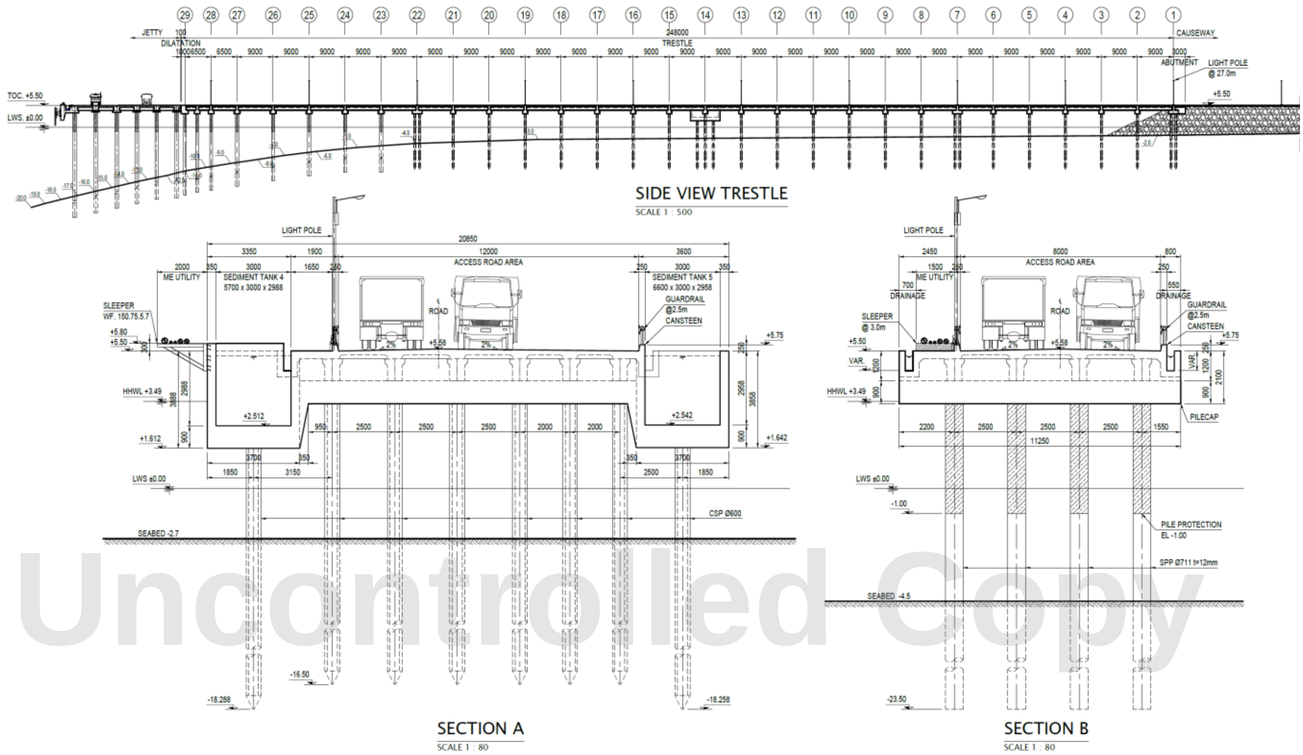


Figure 1.5 Section of Trestle

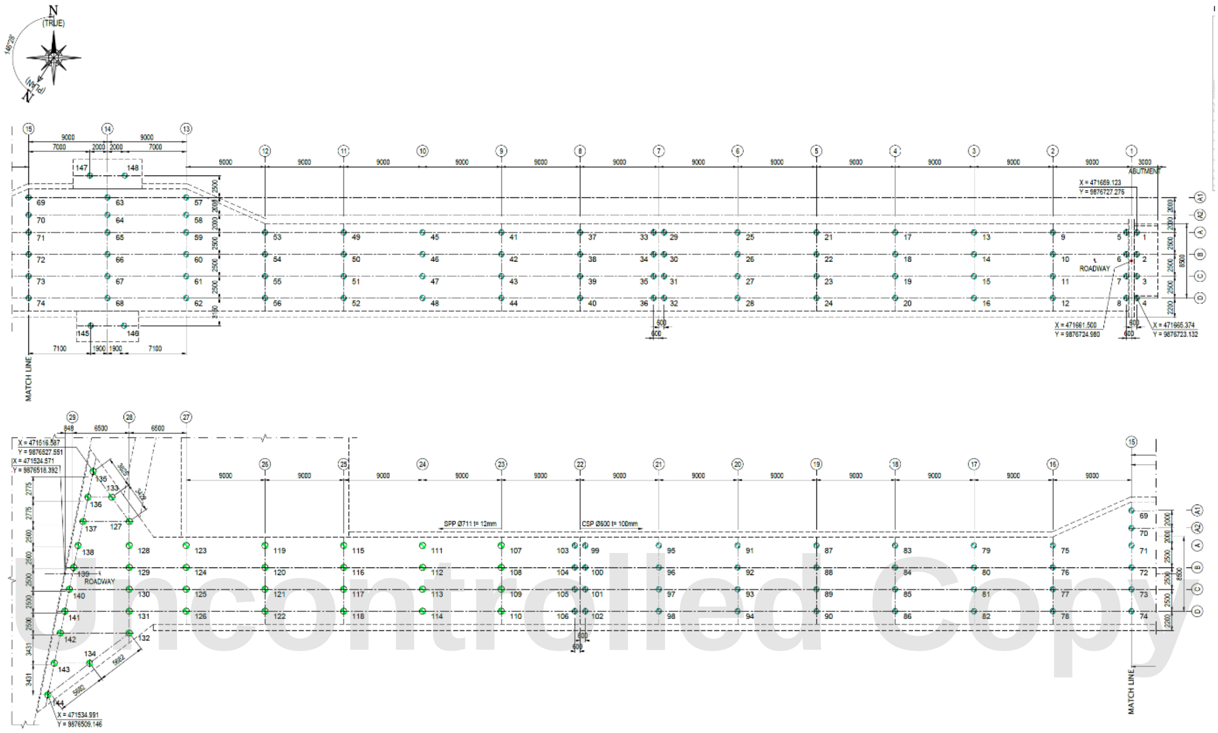


Figure 1.6 Piling Arrangement of Trestle

2 DESIGN CRITERIA

2.1 Codes, Standards, and References

The following documents and codes shall be applied in the design:

Indonesian standards and regulations

SNI 1726:2019	Tata cara perencanaan ketahanan gempa untuk struktur bangunan gedung dan nongedung (Code for seismic design for buiding and non-building)
SNI 1727:2020	Beban desain minimum dan kriteria terkait untuk bangunan gedung dan struktur lain (Code for minimum design loads for building and other structure)
SNI 1729:2020	Spesifikasi untuk bangunan gedung baja struktural (Design standard steel structure for building)
SNI 2847:2019	Persyaratan beton struktural untuk bangunan gedung dan penjelasan (Code for concrete structure design for building)

International codes and standards

ACI 318	Building Code Requirements for Structural Concrete and Commentary
AISC	American Institute of Steel Construction
BS 5950	Structural Use of Steelwork in Building
BS 6349	Code of Practice for Maritime Structures
BS 8004	Code of Practice for Foundation
OCDI	Technical Standards for Port and Harbour Facilities in Japan, by the Overseas Coastal Area Development Institute of Japan
PIANC	Guidelines for the Design of Fenders Systems

Document references

Laporan Soil Investigation – Rencana Pembangunan Nickel Smelter. December 2021. Prepared by PT Bumi Indonesia.
Report Survey Bathymetri & Hidrografi PT MMP. 2020. Prepared by PT Bumi Indonesia.
BED Basic Design Criteria. February 2022. Prepared by PT WIKA
MMP-DBS-100-C-0001 Jetty Design Basis & Criteria Rev. 1. Dated: 16 April 2022. Prepared by PT WIKA

MMP-DBS-100-C-0003 Factual Report – Geotechnical Report (Soil Report) 3 Additional Boreholes Rev.0. Dated: 13 April 2022. Prepared by PT WIKA

2.2 Design Life

The design life service of the marine structures shall be 20 years. Appropriate periodic maintenance and precaution step should be done to increase the lifetime of short-time elements such as guardrail, fenders, ladder, berth light, and others.

2.3 Water Levels

Reference levels for marine facilities structure used in Basis Design should refer to Lowest Water Spring (LWS) or called Chart Datum Level (CDL) ±0.00 m. According to Document Report Survey Bathymetri & Hidrografi PT MMP by PT Bumi Indonesia in 2020, the following are water levels in port area.

- Highest High Water Level (HHWL) : +3.49 mCDL
- Mean High Water Level (MHWL) : +2.82 mCDL
- Mean Sea Level (MSL) : +1.70 mCDL
- Mean Low Water Level (MLWL) : +0.56 mCDL
- Lowest Water Spring (LWS) : ±0.00 m
- Lowest Low Water Level (LLWL) : -0.21 mCDL

2.4 Material Properties

2.4.1 Reinforced Concrete

Minimum concrete grade for marine structure shall be minimum at f'c = 35 MPa (cylinder compressive strength) at 28 days.

2.4.2 Reinforcement Bar

Steel reinforcement in this project will have the following characteristic.

- Plain rebar fy = 280 MPa
- Deformed bar fy = 420 MPa
- Young modulus Es = 200,000 MPa

2.4.3 Structural Steel

The steel profile will be in accordance to JIS G3101 or ASTM A36 with minimum yield strength of 2400 kg/cm^2 (fy = 235 MPa).

2.4.4 Steel Pipe Piles for Foundation

Steel pipe piles will comply with ASTM A252 Grade 3 with yield strength (fy) of 310 MPa, with modulus of elasticity (Es) is 200,000 MPa.

The diameter of steel pipe pile used for trestle structure is 711 mm.

2.4.5 Prestressed Concrete Spun Piles for Foundation

The design and materials specification for concrete spun pile shall comply with SNI 2847:2019 and other relevant codes. Minimum concrete grade for concrete pile is 52 MPa (cylinder compressive strength) at 28 days.

The diameter of prestressed concrete spun pile used for trestle structure is 600 mm with 100 mm of thickness.

2.5 Marine Growth

Marine growth shall be considered in the design. In the absence of marine growth data, the marine growth thickness is taken maximum at 150 mm. With this assumption, it is necessary to control, inspect, and maintain the growth of marine organisms during the service life of the structure.

The addition of marine growth is applied to all construction elements from HHWL to the design seabed level.

2.6 Design Elevations

Refer to Document Jetty Design Basis & Criteria (Doc. No. MMP-DBS-100-C-0001 Rev. 01, Section 2.3 and 4.5), the design elevations design for trestle structure are as follows:

- Deck elevation = +5.50 mCDL
- Seabed elevation = var. -2.00 to -11.00 mCDL

3 DESIGN LOADS

Loadings on trestle structure corresponds to the design load written in the Document Jetty Design Basis & Criteria (Doc. No. MMP-DBS-100-C-0001 Rev. 01, Section 4.7).

3.1 Dead Loads and Superimposed Dead Loads

Dead loads are the weight of the structural members considering specific gravity of the material, as follows:

- Steel structure : 7.85 ton/m^3 (78.5 kN/m^3)
- Concrete : 2.40 ton/m^3 (24.0 kN/m^3)
- Reinforced concrete : 2.50 ton/m^3 (25.0 kN/m^3)

Self-weight of the structure calculated automatically by software and for self-weight of infill concrete and other equipment will be considered as superimposed dead loads.

- Weight of infill concrete = SPP Ø 711.2, t =12 mm with length of infill concrete is 1.5 m
  = 1.39 ton (13.9 kN)
- Weight of infill concrete = CSP Ø 600, t =100 mm with length of infill concrete is 1.5 m
  = 0.47 ton (4.71 kN)

3.2 Live Load (Distributed Load)

Live load shall be uniformly distributed over the specified areas. Live load for trestle is taken 1.50 ton/m^2 (or 15 kN/m^2).

According to SNI 1725:2016 (Design Load for Bridge), distributed load for bridge with traffic of 50 ton truck is 9.0 kPa. In this project, with considering the different types of truck and another vehicle or mobile crane that will occasionally drive along the trestle and referring to a typical project, then the distributed load on trestle is taken 1.5 ton/m^2 (15 kN/m^2).

Concentrated line load (BGT) with an intensity of 49 kN/m should be placed perpendicular to the direction of traffic on the trestle. The location of the load will be placed in a position that provides maximum force on the bridge.

3.3 Major Handling Equipment

Trucks and equipment that will operate or drive along the trestle are included in the type of live load, which is a live load that acts and is applied as a concentrated load from the wheels or outriggers or other type of support systems. In the load combination, these loads are included as L (Live Load).

Major handling equipment that will operate on the trestle as follows:

3.3.1 Flatbed Truck

Flatbed truck with 40 ton capacity will mobilize with full load capacity along the trestle. Specification and loading data of flatbed truck will be informed after it is decided which type will be used in operations.

3.3.2 Dump Truck

Dump truck with 40 ton capacity (30 m^3) will mobilize with full load capacity along the trestle. Specification and loading data of dump truck will be informed after it is decided which type will be used in operations.

For design and analysis of trestle at Basic Design stage, this load has been covered by distributed live load.

3.3.3 Single Bucket Loader

Single bucket loader with 5 m^3 capacity will driving with empty load along the trestle. Specification and loading data of single bucket loader will be informed after it is decided which type will be used in operations.

Since this equipment/ heavy vehicle only passes through the trestle occasionally and does not queue, then for design and analysis of trestle at Basic Design stage, this load has been covered by distributed live load.

3.3.4 Truck Crane

Truck crane (40 ton) with lifting weight of 16 ton will driving with empty load along the trestle. Specification and loading data of truck crane will be informed after it is decided which type will be used in operations.

Since this equipment/ heavy vehicle only passes through the trestle occasionally and does not queue, then for design and analysis of trestle at Basic Design stage, this load has been covered by distributed live load.

3.3.5 Crawler Excavator

Crawler excavator with 30 ton capacity will driving with empty load along the trestle. Specification and loading data of crawler excavator will be informed after it is decided which type will be used in operations.

Since this equipment/ heavy vehicle only passes through the trestle occasionally and does not queue, then for design and analysis of trestle at Basic Design stage, this load has been covered by distributed live load.

3.3.6 Mobile Crane

Mobile crane with 150 ton capacity will driving with empty load along the trestle. Specification and loading data of mobile crane will be informed after it is decided which type will be used in operations.

Since this equipment/ heavy vehicle only passes through the trestle occasionally and does not queue, then for design and analysis of trestle at Basic Design stage, this load has been covered by distributed live load.

3.4 Pipe Loads

Pipe loads considered in the basic design has been covered by distributed live load.

3.5 Electrical and Instrument Loads

Electrical and instrument loads on tray above the trestle deck considered in the basic design has been covered by distributed live load.

3.6 Environment Loads

In designing the environmental loads on structures should be considered the site conditions that have been obtained from survey works and BMKG data as secondary data.

3.6.1 Current Loads

The current induced drag loads on piles is calculated by the following formula based on BS 6349-1-2:2016.

$$F_D = \frac{1}{2}(C_D \rho V^2 A_n)$$

Where:

F_D = steady drag force (N)

C_D = dimensionless time-averaged drag coefficient for steady flow

ρ = mass density of the water (kg/m^3)

V = incident current velocity (m/s)

A_n = area of structural member normal to flow (m^2)

Current data is taken from Document Report Survey Bathymetri & Hidrografi PT MMP provided by PT Bumi Indonesia in 2020. The current condition in the project area based on observations at February 7, 2021 is quite calm, with average of current velocity of 1.30 km/hr and the maximum current velocity is at 2.60 km/hr.

This data will be verified with observations and survey works in project area. However, data from PT Bumi Indonesia can be used as reference for Basic Engineering Design stage and will be adjusted after survey data is available.

For structural analysis, current velocities are taken:

- Normal condition = 1.30 km/hr (or 0.361 m/s)
- Extreme condition = 2.60 km/hr (or 0.722 m/s)

Marine growth of 150 mm of thickness will be considered in the design of current force on piles.

Current force acting on the piles is calculated as follows:

Applied on Pile SPP 711 at Normal Condition:

Density of fluid	ρ	=	1.025 t/m^3
Pile Diameter	D	=	0.711 m
Drag Coefficient	C_D	=	1.0
Marine growth		=	150 mm

Diameter with 150 mm marine growth, D' = 1.011 m

Current velocity	V	=	0.701 knot(s)
	V	=	0.361 m/s
Area of structure	A_n	=	1.588 m^2 (per 1 m height)
Steady drag force	F_D	=	0.106 kN/m height
	F_D	=	0.011 t/m height

Applied on Pile SPP 711 at Extreme Condition:

Density of fluid	ρ	=	1.025 t/m^3
Pile Diameter	D	=	0.711 m
Drag Coefficient	C_D	=	1.0
Marine growth		=	150 mm

Diameter with 150 mm marine growth, D' = 1.011 m

Current velocity	V	=	1.402 knot(s)
	V	=	0.722 m/s
Area of structure	A_n	=	1.588 m^2 (per 1 m height)
Steady drag force	F_D	=	0.424 kN/m height
	F_D	=	0.043 t/m height

Applied on Pile CSP 600 at Normal Condition:

Density of fluid	ρ	=	1.025 t/m^3
Pile Diameter	D	=	0.600 m
Drag Coefficient	C_D	=	1.0
Marine growth		=	150 mm

Diameter with 150 mm marine growth, D' = 0.900 m

Current velocity	V	=	0.701 knot(s)
	V	=	0.361 m/s
Area of structure	A_n	=	1.414 m^2 (per 1 m height)
Steady drag force	F_D	=	0.094 kN/m height
	F_D	=	0.010 t/m height

Applied on Pile CSP 600 at Extreme Condition:

Density of fluid	ρ	=	1.025 t/m^3
Pile Diameter	D	=	0.600 m
Drag Coefficient	C_D	=	1.0
Marine growth		=	150 mm

Diameter with 150 mm marine growth, D' = 0.900 m

Current velocity	V	=	1.402 knot(s)
	V	=	0.722 m/s
Area of structure	A_n	=	1.414 m^2 (per 1 m height)
Steady drag force	F_D	=	0.378 kN/m height
	F_D	=	0.039 t/m height

3.6.2 Wind Loads

The wind load acting on the structure shall be calculated based on BS 5400-2:2006, with following equation:

$$P_t = q \times A \times C_D$$

$$q = 0.613 \times V_C^2$$

Where:

P_t = wind load (N)

q = dynamic pressure head (N/m², $q = 0.613\ V_C^2$)

A = solid area (m²)

C_D = drag coefficient (from Figure 5 and Tables 9 from BS 5400-2)

V_C = design wind speed (m/s)

Wind data at project area is taken from BMKG (Meteorological, Climatological, and Geophysical Agency) in BMKG Sultan Aji Muhammad Sulaiman Sepinggan. Wind conditions at site are summarized below:

- Max. wind speed = 25 knots
- Dominant wind speed = 3-6 knots (46.0% per year)
- Dominant wind direction = South – Southwest (37.87% per year)

The wind speed data above is considered relatively small, then for structural analysis the wind speeds are taken:

- Normal condition = 40 km/hr
- Extreme condition = 120 km/hr

Wind forces acting on the structure are calculated as follows:

- Normal condition

<u>Applied on Deck</u>

Wind speed	V_C	=	11.11	m/s
Dynamic pressure head	q	=	75.68	N/m²
At X-direction (Parallel to Jetty)				
Breadth	b	=	11.25	m
Height	d	=	1.20	m
Breadth/Height	b/d	=	9.38	
Drag coefficient at x-direction	C_{DX}	=	1.30	
Solid area at x-direction	A_X	=	1.20	m² (per 1 m wide)
wind load at x-direction	P_{tx}	=	118.059	N/m wide
		=	0.012	t/m wide

Applied on Pile CSP 600 mm:

Wind speed	V_C	=	11.11	m/s
Dynamic pressure head	q	=	75.68	N/m^2
Drag coefficient	C_D	=	0.50	
Diameter of pile	D_{pile}	=	0.600	m
Solid area	A_{pile}	=	0.942	m^2 (per 1 m height)
Wind load	$P_{t(pile)}$	=	35.663	N/m height
		=	3.64E-03	t/m height

Applied on Pile SPP 711 mm:

Wind speed	V_C	=	11.11	m/s
Dynamic pressure head	q	=	75.68	N/m^2
Drag coefficient	C_D	=	0.50	
Diameter of pile	D_{pile}	=	0.711	m
Solid area	A_{pile}	=	1.117	m^2 (per 1 m height)
Wind load	$P_{t(pile)}$	=	42.261	N/m height
		=	4.31E-03	t/m height

- Extreme condition

Applied on Deck

Wind speed	V_C	=	33.33	m/s
Dynamic pressure head	q	=	681.11	N/m^2

At X-direction (Parallel to Jetty)

Breadth	b	=	11.25	m
Height	d	=	1.20	m
Breadth/Height	b/d	=	9.38	
Drag coefficient at x-direction	C_{DX}	=	1.30	
Solid area at x-direction	A_X	=	1.20	m^2 (per 1 m wide)
wind load at x-direction	P_{tx}	=	1062.53	N/m wide
		=	0.108	t/m wide

Applied on Pile CSP 600 mm:

Wind speed	V_C	=	33.33	m/s
Dynamic pressure head	q	=	681.11	N/m^2
Drag coefficient	C_D	=	0.50	
Diameter of pile	D_{pile}	=	0.600	m
Solid area	A_{pile}	=	0.942	m^2 (per 1 m height)
Wind load	$P_{t(pile)}$	=	320.966	N/m height
		=	0.033	t/m height

Applied on Pile SPP 711 mm:

Wind speed	V_C	=	33.33	m/s
Dynamic pressure head	q	=	681.11	N/m^2
Drag coefficient	C_D	=	0.50	
Diameter of pile	D_{pile}	=	0.711	m
Solid area	A_{pile}	=	1.117	m^2 (per 1 m height)
Wind load	$P_{t(pile)}$	=	380.345	N/m height
		=	0.039	t/m height

3.6.3 Wave Loads

Waves condition at site is determined with modelling and hindcasting from wind data obtained from BMKG. From the modelling, wave conditions at site are:

- Max. wave height (offshore) = 0.86 m
- Dominant wave height (offshore) = 0.00 – 0.20 m (46.91% per year)
- Dominant wave direction (offshore) = South – Southwest (37.87% per year)

The results of refraction and diffraction modelling of waves with a return period of 50 years, the wave height (wave for design):

- In front of jetty = 0.840 m
- In front of causeway = 0.732 m

For structural analysis, wave height is taken 0.840 m. Wave induced drag loads on piles is calculated by the following formula based on API WSD – 2000.

3.7 Temperature Load

Temperature is obtained from BMKG Sepinggan Balikpapan and summarized as follow:

- Maximum = 35.2^{o} C
- Minimum = 22.3^{o} C
- Average = 27.7^{o} C

3.8 Seismic Load

Seismic load shall be in accordance with SNI 1726:2019, with return period of 2500 years. Parameters and site coefficients to create response spectrum curve in project location shall be determined from seismic maps which are provided by the Indonesia Seismic Code. The value that can be obtained from these maps are PGA (Peak Ground Acceleration), S_S (response spectral acceleration parameter MCER for T=0.2 sec), and S_1 (response spectral acceleration parameter MCER for T=1.0 sec). An amplification factors are needed for determine response spectrum in the ground surface. The amplification values depend on the soil type.

SNI 1726:2019

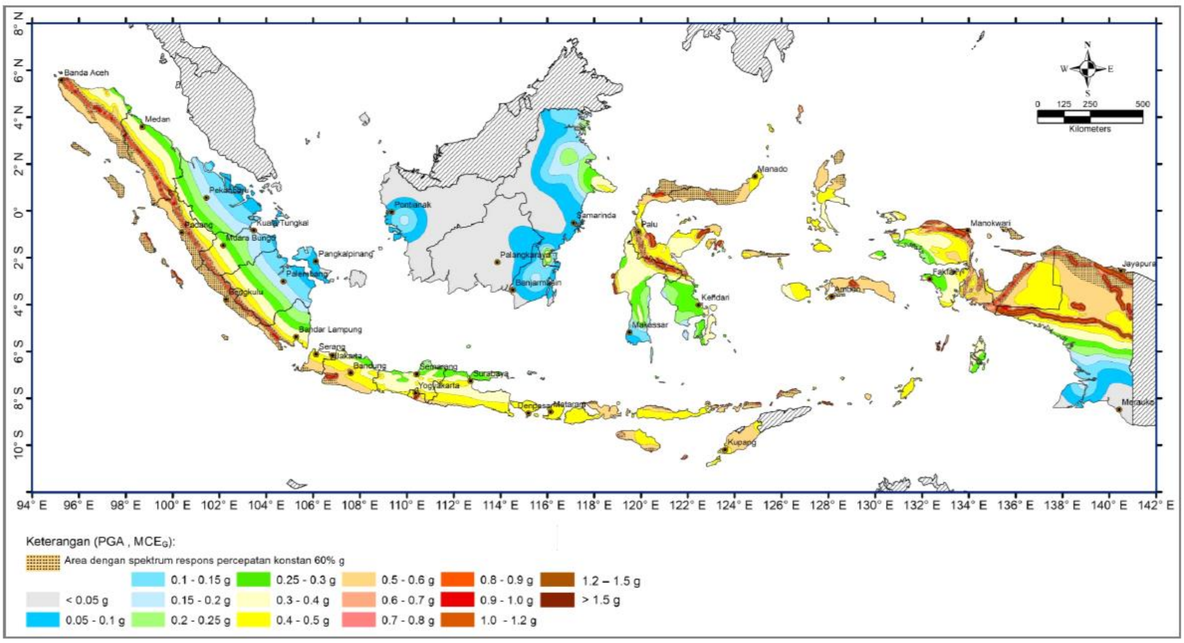


Figure 3.1 PGA. Maximum considered earthquake geometric mean peak ground acceleration (MCE$_G$)

SNI 1726:2019

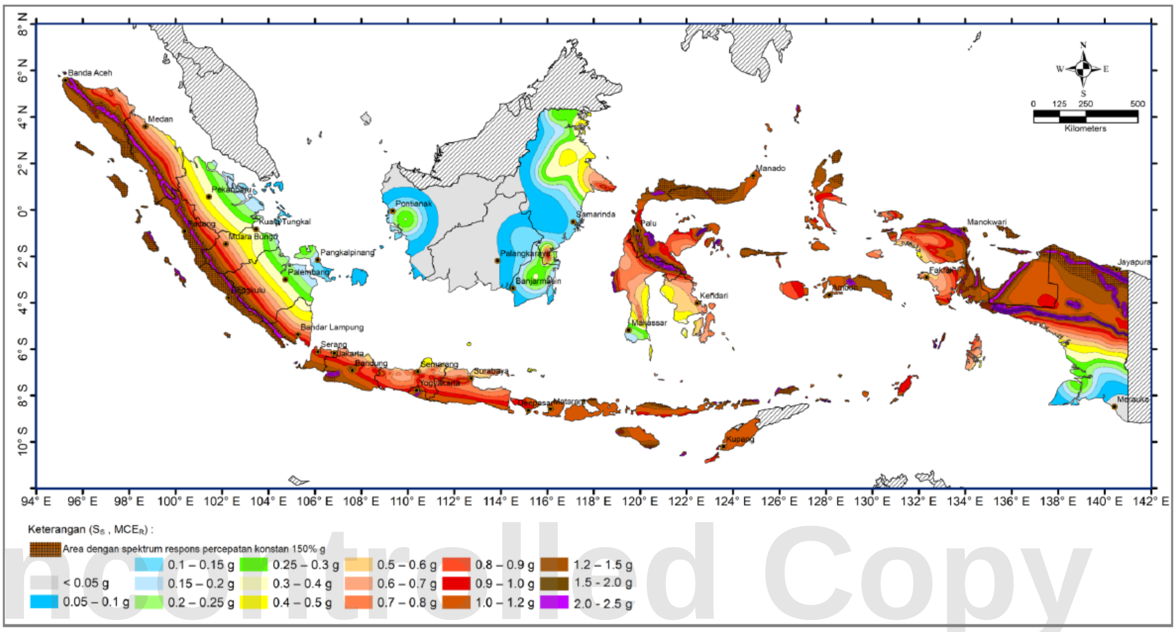


Figure 3.2 Ground Motion Parameter S_S, Risk-Targeted Maximum Considered Earthquake (MCE_R), for 0.2 s Spectral Response Acceleration (5% of Critical Damping)

SNI 1726:2019

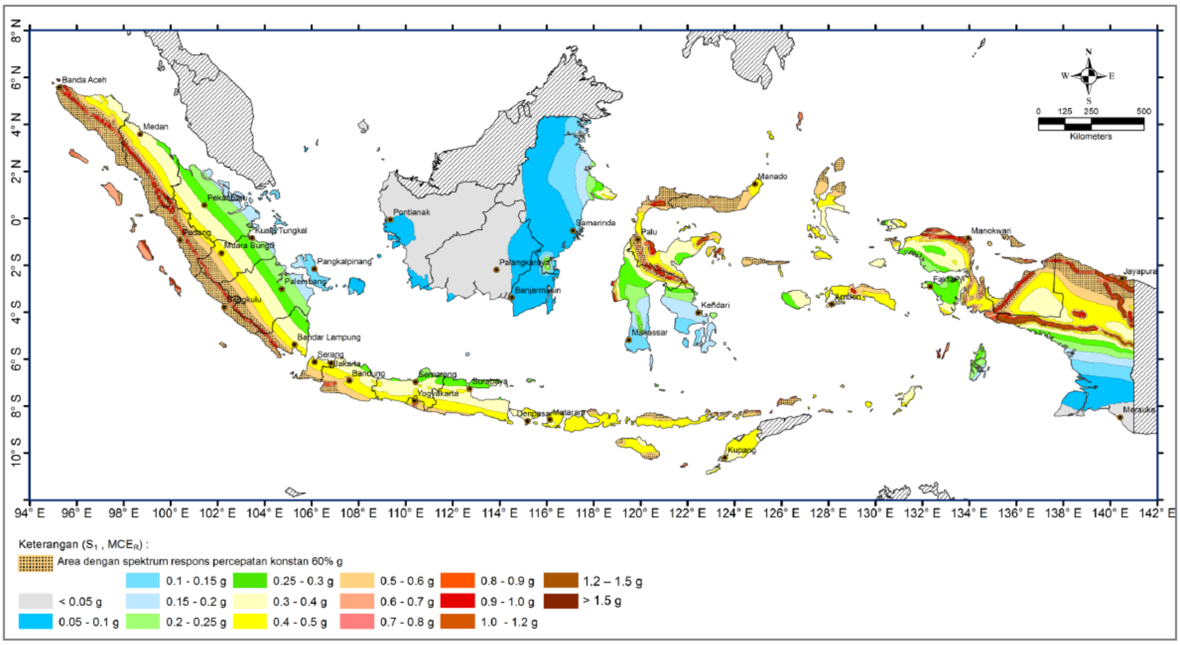


Figure 3.3 Ground Motion Parameter S1, Risk-Targeted Maximum Considered Earthquake (MCER), for 1.0 s Spectral Response Acceleration (5% of Critical Damping)

The seismic design for structures and facilities in this project will be based on Indonesia Seismic Code SNI 1726:2019. Dynamic response spectrum analysis shall be used in the seismic design, with the following parameters:

- Site Class : Soft Soil (SE)
- PGA : 0.056g
- S_S : 0.109g
- S_1 : 0.080g
- Important factor, I : 1.0
- 10% of distributed live load will be considered during earthquake

According to the soil data obtained from investigation works at trestle and jetty area, there are differences in soil stratigraphy and the depth of the hard soil layer calculated from the seabed elevation. According to the soil data, in the trestle area the soil condition is included in the site class 'SD – Medium Soil', while in the jetty area it is included in the site class 'SE – Soft Soil'. Therefore, at the basic design stage, the site class for the trestle area will use the SE type as a conservative value. However, for the detail design stage, a more detailed study will be conducted to determine the class of this site.

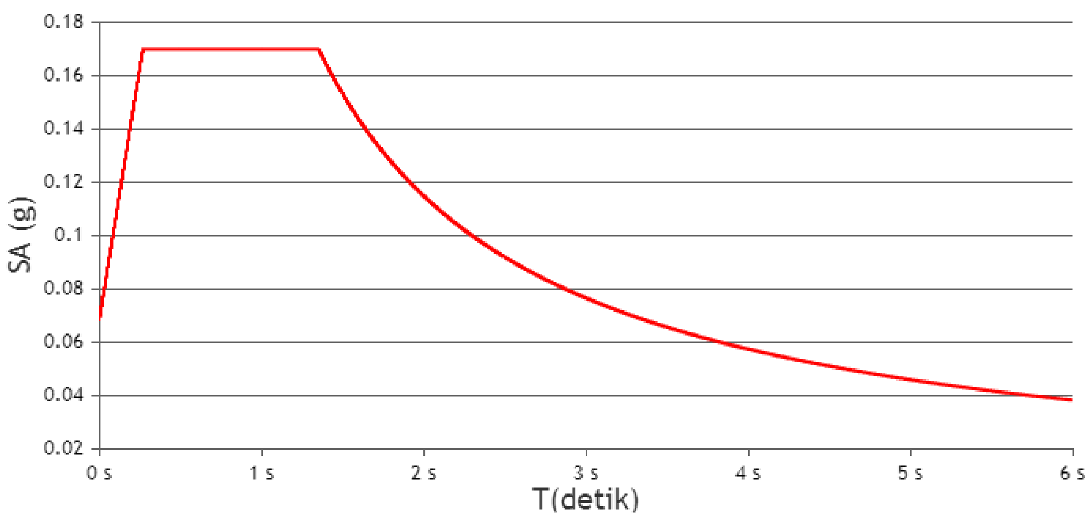


Figure 3.4 Response Spectrum Design (Ref. SNI 1726:2019 – Site Class SE)

For seismic loading condition, the following directions shall be combined to produce the largest demand on the structure

- ±100% EQx ±30% EQy
- ±30% EQx ±100% EQy

3.9 Load Combinations

Load combination shall be designed to ensure application of the worst load combination for sizing of, and determination of maximum stress levels in the individual members of the structure. Where applied wind, wave, or current loads cause lower stress levels than without their exposure, their effects shall be eliminated from the relevant load combination. The upper structure should be designed to resist all combination of loads which may realistically be assumed to act on the structure simultaneously. Loads may act directly on the upper structure or indirect via the piles. Basis of load combinations for marine structure shall be based on American Standard which are described in the POLB WDC (Port of Long Beach) and for earthquake loads shall be calculated based on SNI 1726:2019.

<u>Basic load combinations for Operational Condition (Basis Ref.: American Standard/ POLB):</u>

Service Design

Service Design Load (SLD)/ Allowable Stress Design (ASD)							
Load Combination	**D**	**L**	**W**	**BE**	**MO**	**T**	**C**
Comb 1	1.00	-	0.60	-	-	1.00	1.00
Comb 2	1.00	1.00	0.60	-	-	1.00	1.00

Ultimate Design

Load and Resistance Factor Design (LRFD)							
Load Combination	**D**	**L**	**W**	**BE**	**MO**	**T**	**C**
Comb 1	0.90	-	1.00	-	-	1.20	1.20
Comb 2	1.40	-	1.00	-	-	-	1.40
Comb 3	1.20	1.60	1.00	-	-	1.20	1.20

Where:

D = Dead Loads (include Superimposed Dead Load)

L = Live Loads (include Major Material Handling)

W = Wind Loads

BE = Berthing Loads

MO = Mooring Loads

T = Temperature Load

C = Current Loads on Structure

<u>Basic load combination for Seismic Loads (Ref.: SNI 1726:2019):</u>

Service Design

1. Comb 1 : $1.0D + 0.7E_v + 0.7E_h$
2. Comb 2 : $1.0D + 0.525E_v + 0.525E_h + 0.75L$
3. Comb 3 : $0.6D – 0.7E_v + 0.7E_h$

Ultimate Design

Comb 1 : $1.2D + E_v + E_h + L$

Comb 2 : $0.9D – E_v + E_h$

Where:

D = Dead Loads (include Superimposed Dead Load)

L = Live Loads

E_h = Horizontal Seismic Load

E_v = Vertical Seismic Load

4 STRUCTURAL ANALYSIS FOR TRESTLE

4.1 Computer Model

Structural modeling was undertaken using well known computer structural analysis program named SAP2000.

The 3-D computer model was used in this analysis. The structures will be analyzed under critical combination of vertical, longitudinal, and lateral loads. A 3-D dimension frame model will be built up with all structural components represented by at least one element, the piles will be considered as rigidly connected to the superstructure. The pile-soil interaction will be modeled by providing a fixed-point level from the seabed. In this case it is calculated by fixity calculation.

The output of the computer run provides data on maximum and minimum axial force, bending moment, shear forces, and deflection for each of the elements to be designed or checked.

4.2 Elevation

The 3-D computer model elevations will be as follow:

- Deck Elevation, DE = +5.50 m from CDL
- Seabed Elevation, SE = -var. -2.00 mCDL to -11.00 mCDL
- Fixity Level (SPP 711mm) = 6.61 m from Seabed (determination of fixity level is presented in Section 4.3)
- Fixity Level (CSP 600mm) = 5.87 m from Seabed (determination of fixity level is presented in Section 4.3)

4.3 Fixity Point

Soils contacting with the piles will be modeled as fixity point. The virtual fixed points of the piles may be considered to be located at a depth of 1/β below the virtual ground surface. Calculation of β is using the following formulation: (Ref. OCDI)

$$\beta = \sqrt[4]{\frac{k_{CH} D}{4EI}}$$

Where:

1/β = virtual fixity point (cm)

kCH = lateral subgrade reaction coefficient (N/cm3)

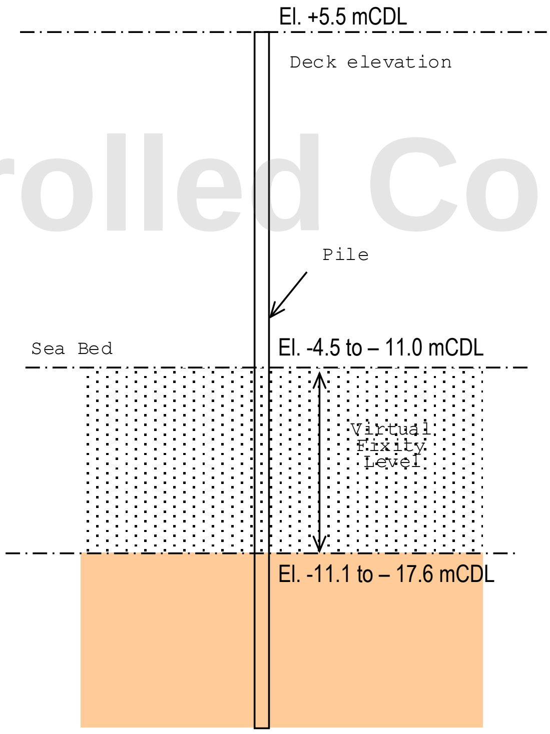
= 1.5 N

N = average N-value of the ground down to a depth of about 1/β

D = diameter or width of the pile (cm)

EI = flexural rigidity of the pile (N.cm^2)

Calculation of Fixity Point *SPP D = 711 mm and thk. 12 mm*



Soil Investigation Result:

N = 1.00

k_{CH} = 1.50 N/cm^3

Section Properties:

Diameter of Pile

D = 71.12 cm

ID = 68.72 cm

Thickness

t = 1.2 cm

Area of Section

A = 263.59 cm^2

Modulus Inertia

I = 161128.84 cm^4

Steel Grade

f_y = 310 MPa

= 31000 N/cm^2

Elasticity Modulus (E)

E_s = 200000 MPa

= 20000000 N/cm^2

Virtual Fixity (Z_f)

Z_f = 1/β

= 590 cm

Scouring Depth (SD)

SD = 71.1 cm

Total Fixity Level (Z_f')

Z_f' = 661 cm

Calculation of Fixity Point *CSP D = 600 mm and thk. 100 mm*

Soil Investigation Result:

N = 1.00

k_{CH} = 1.50 N/cm^3

Section Properties:

Diameter of Pile

D = 60.00 cm

ID = 40.00 cm

Thickness

t = 10 cm

Area of Section

A = 1570.80 cm^2

Modulus Inertia

I = 510508.81 cm^4

Concrete Grade

f_c = 52 MPa

= 5200 N/cm^2

Elasticity Modulus (E)

E_c = 33892 MPa

= 3389218 N/cm^2

Virtual Fixity (Z_f)

$Z_f = 1/\beta$

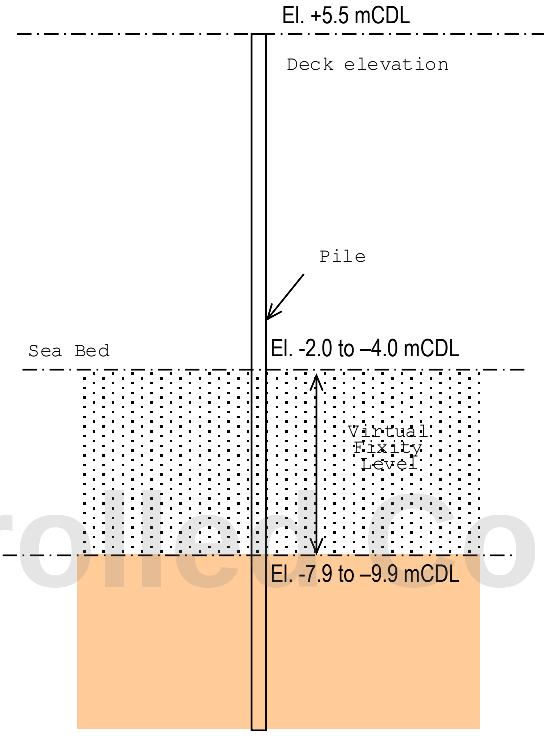
= 527 cm

Scouring Depth (SD)

SD = 60.0 cm

Total Fixity Level (Z_f')

Z_f' = 587 cm



4.4 Section Property

The section properties of individual members used in the computer models are shown in the following table.

No.	Elemen Structure	Details
1	Pile foundation	Steel Pipe Pile (SPP) • Outer diameter, OD = 711.2 mm • Inner diameter, ID = 687.2 mm • Wall thickness, t = 12 mm • Yield strength, fy = 310 MPa • Length in the model, L = 16.6 m – 23.1 m Concrete Spun Pile (CSP) • Outer diameter, OD = 600 mm • Inner diameter, ID = 400 mm • Wall thickness, t = 100 mm • Concrete grade, f'c= 52 MPa • Length in the model, L = 13.4 m – 15.4 m
2	Slab	• Thickness, t = 320 mm • Concrete grade, f'c= 35 MPa
3	Main Beam	• Height, H = 1200 mm • Width, B = 600 mm • Concrete grade, f'c= 35 MPa
4	Pilecap for CSP 600	• Height, H = 2100 mm • Width, B = 1200 mm • Concrete grade, f'c= 35 MPa
5	Pilecap for SPP 711	• Height, H = 2100 mm • Width, B = 1400 mm • Concrete grade, f'c= 35 MPa

4.5 Structural Modeling

Plots of 3D model and main loads are shown below:

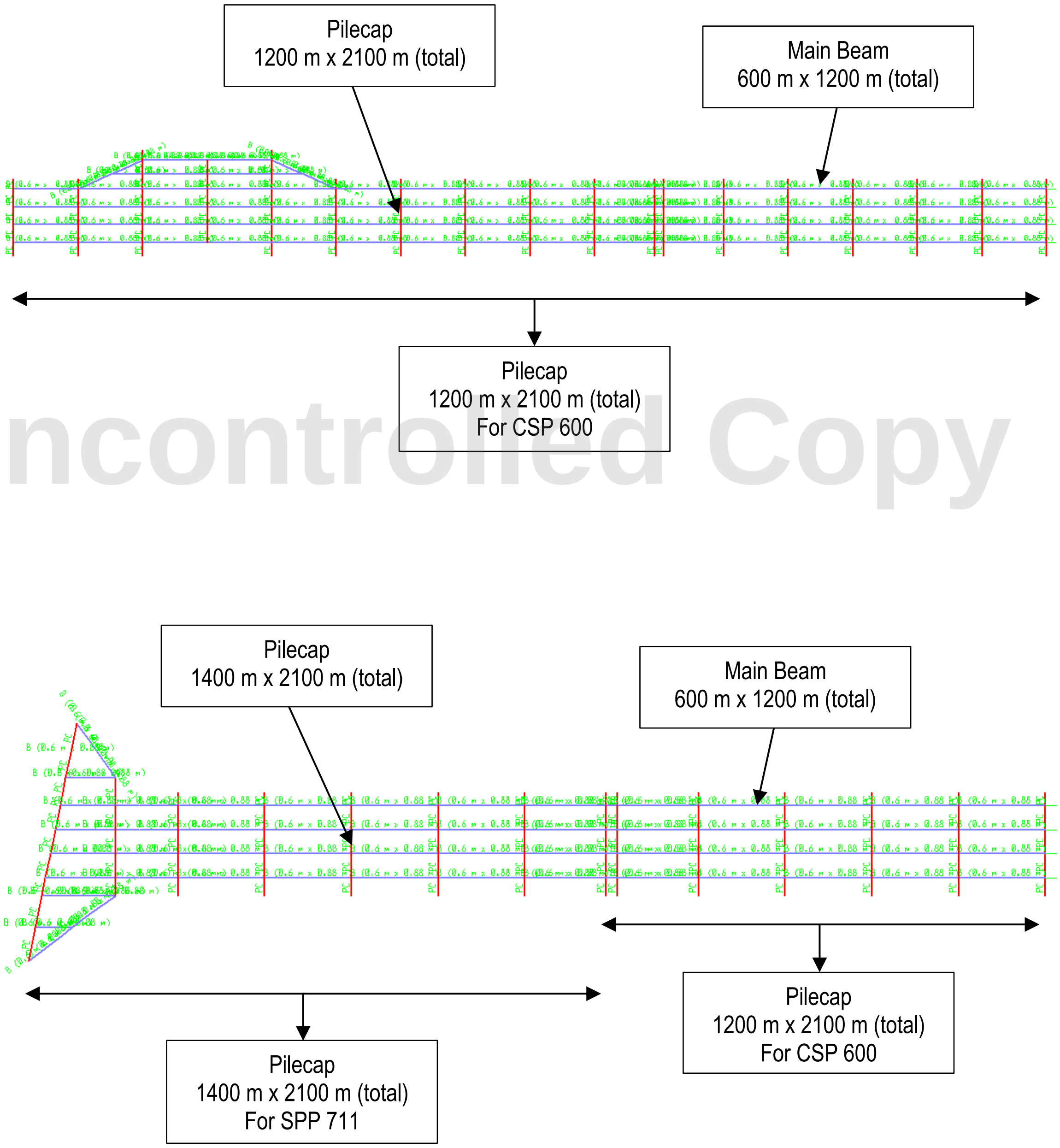
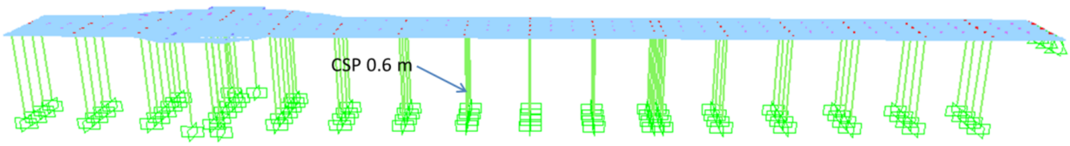
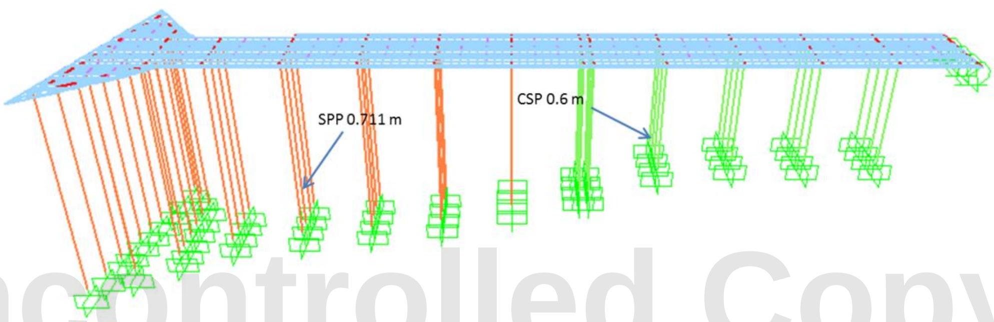


Figure 4.1 Plot Plan 3D Model of Trestle

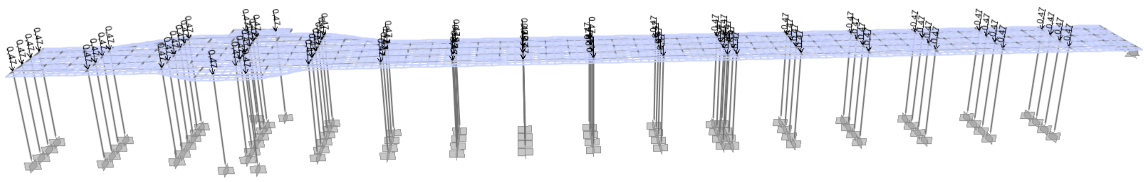


Segment 1

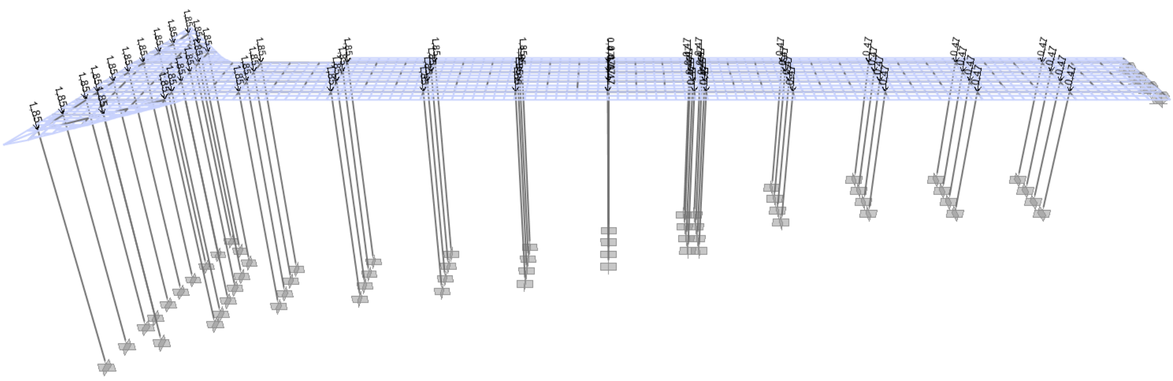


Segment 2

Figure 4.2 Plot 3D Model of Trestle

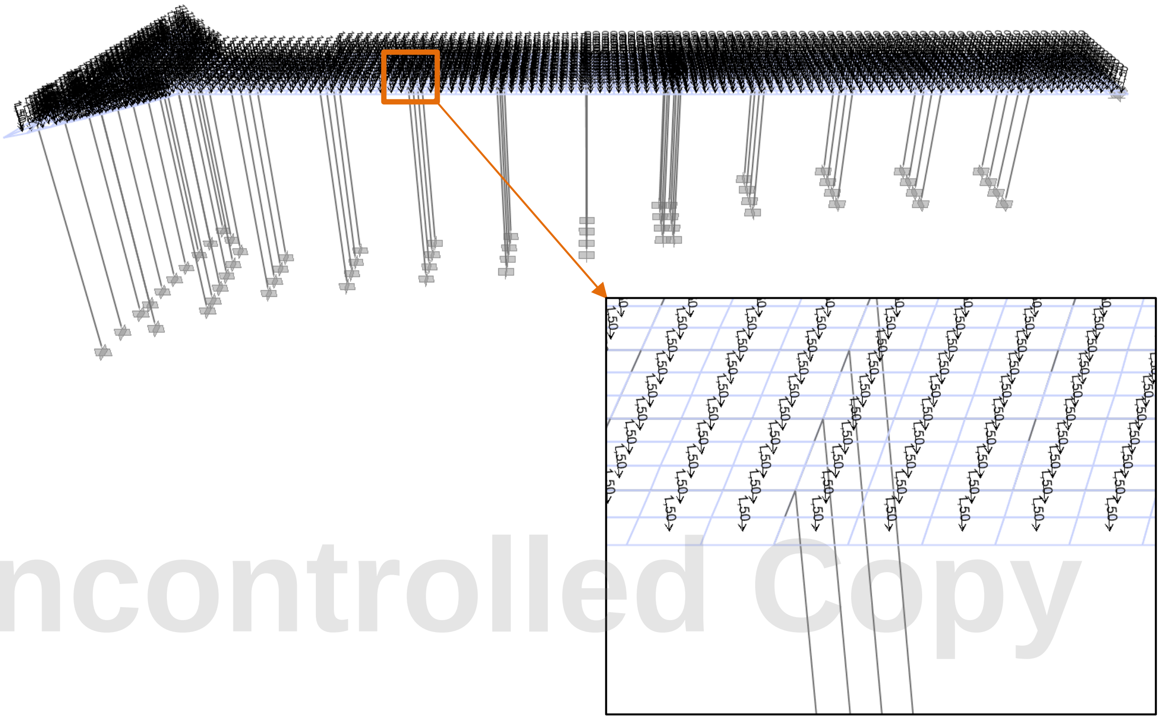


Segment 1

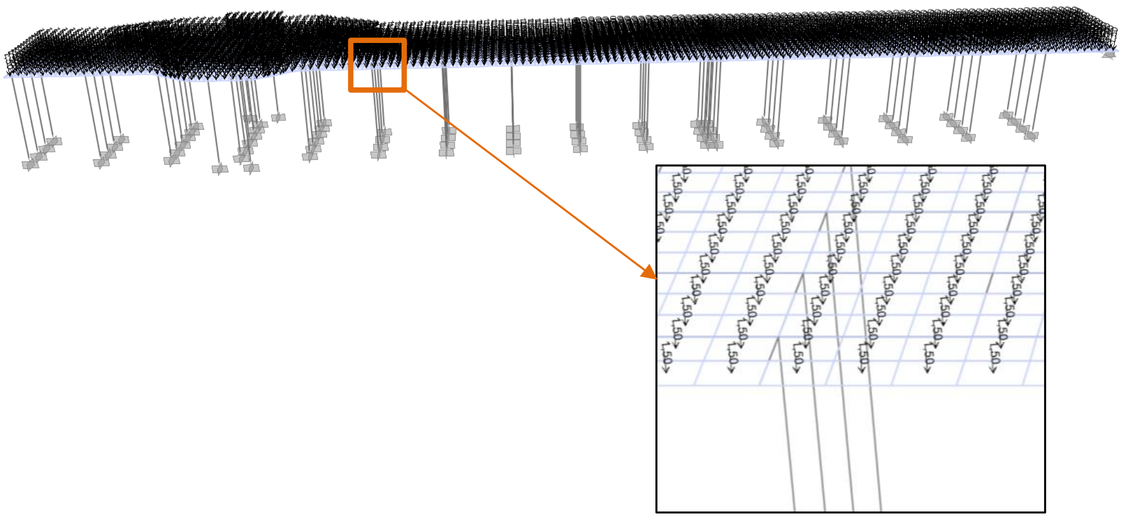


Segment 2

Figure 4.3 Plot of SDL Load

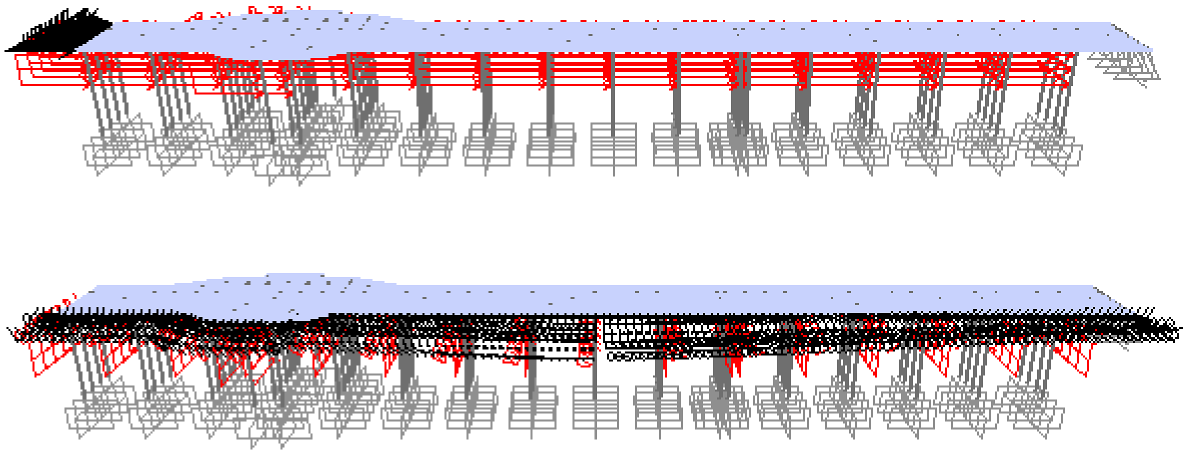


Segment 1

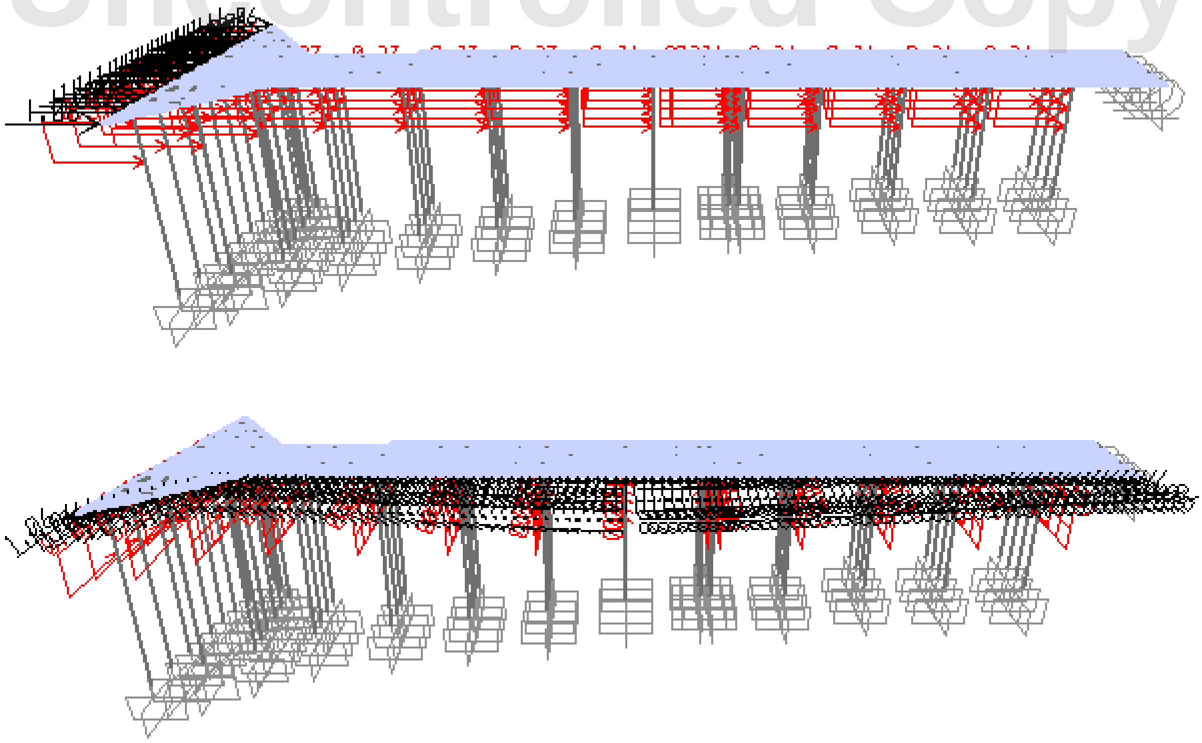


Segment 2

Figure 4.4 Plot of Distributed Live Load on Deck (15 kN/m^2)

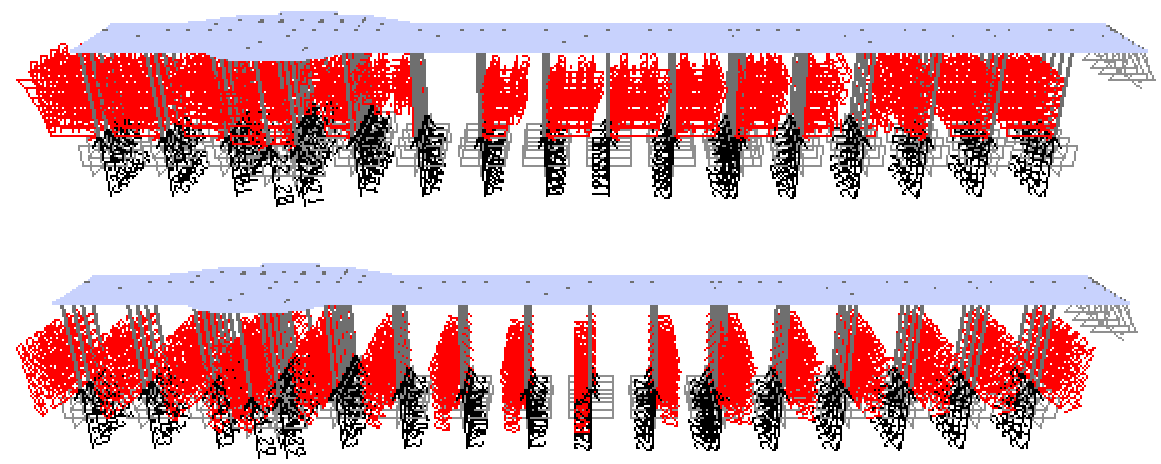


Segment 1

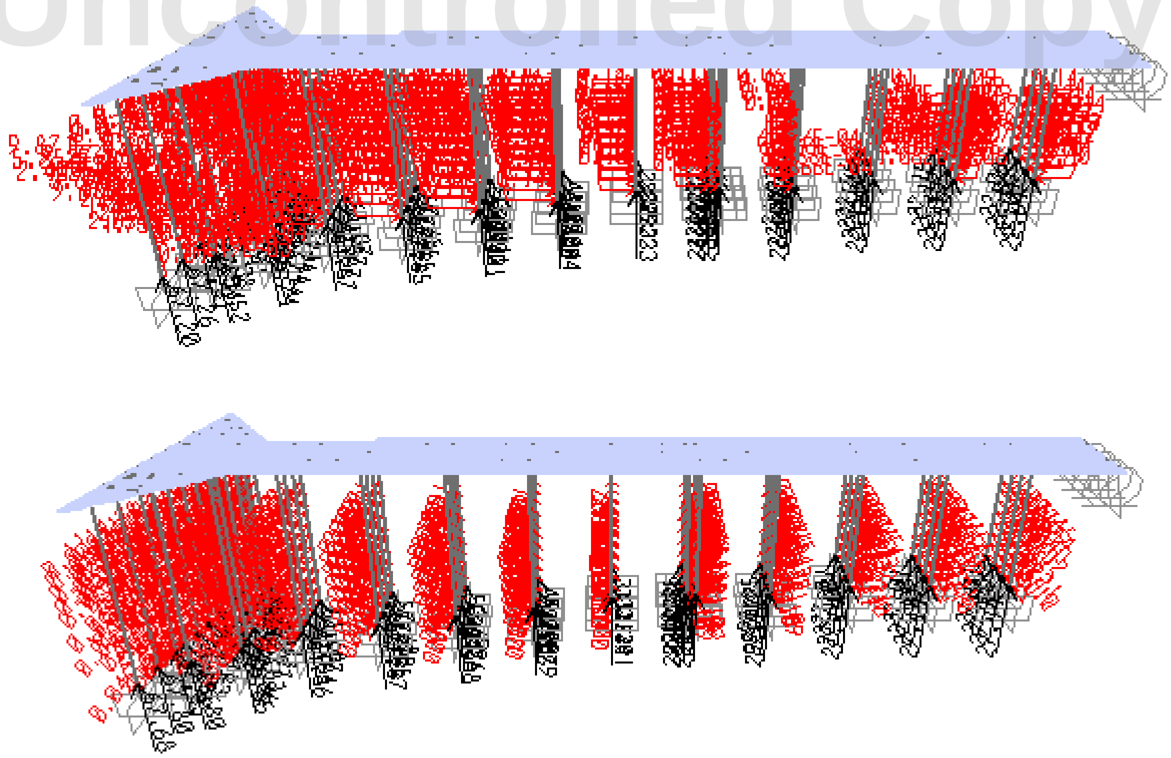


Segment 2

Figure 4.5 Plot of Wind Loads (Unit in ton/m)

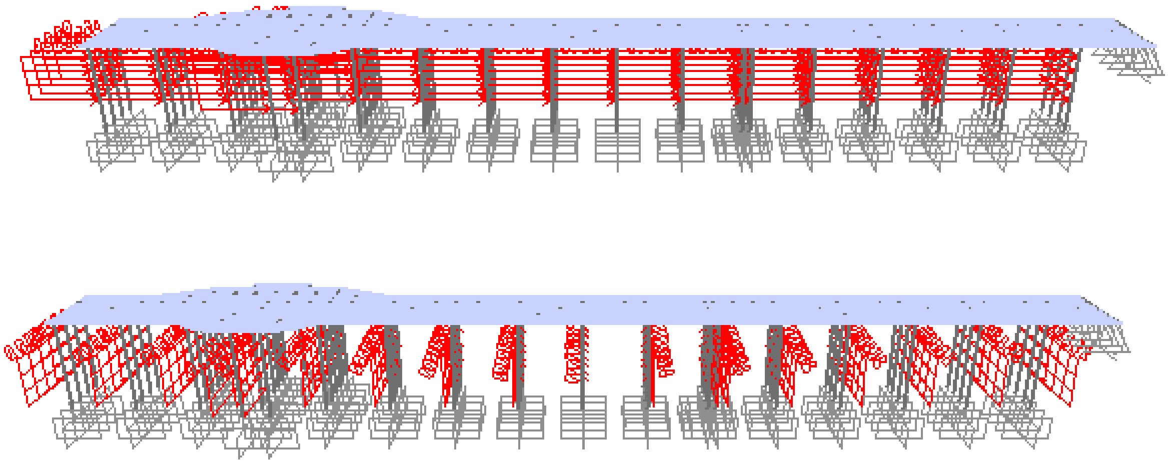


Segment 1

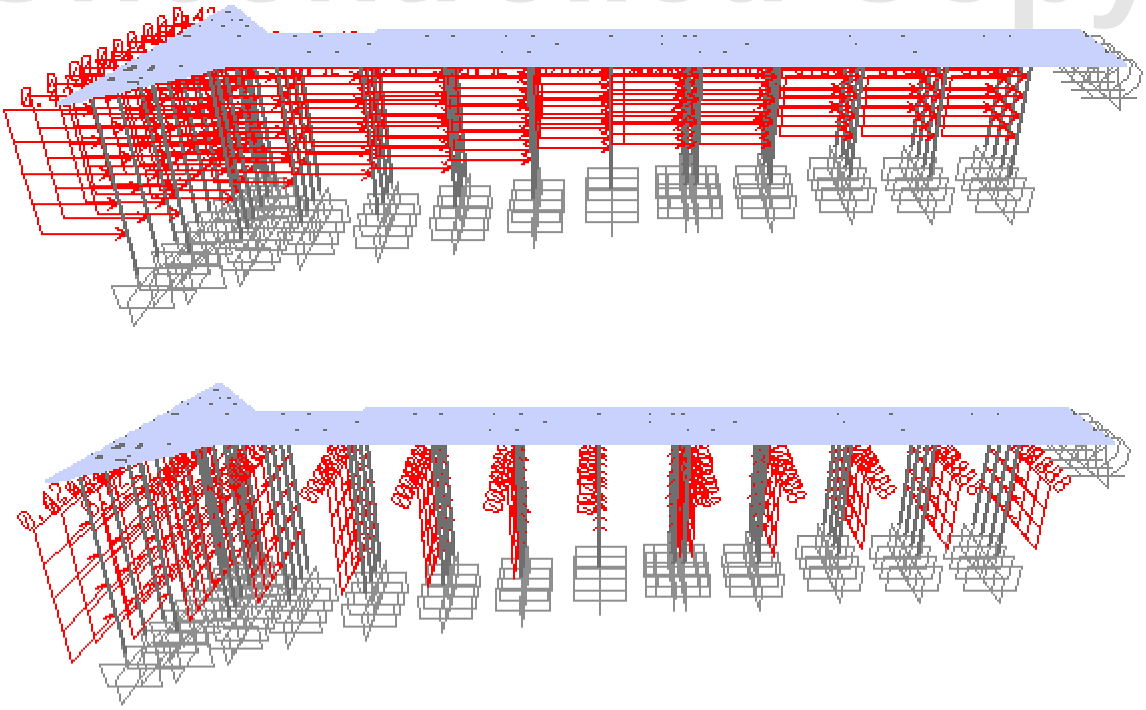


Segment 2

Figure 4.6 Plot of Wave Loads (Unit in ton/m)



Segment 1



Segment 2

Figure 4.7 Plot of Current Loads (Unit in ton/m)

4.6 Substructure Analysis Results

Substructure analysis result consist of the following pile load, pile forces, deflection, dan stress ratio. The results of analysis will be summarized according to the case, as follows:

- Case I = Summary of analysis and combinations that include vertical loads (Dead Load & Live Load) and environmental load

  The service load approach shall be used for substructure design/ pile capacity, with considering following load combinations:

Service Design Load (SLD)/ Allowable Stress Design (ASD)							
Load Combination	**D**	**L**	**W**	**BE**	**MO**	**T**	**C**
Comb 1	1.00	-	0.60	-	-	1.00	1.00
Comb 2	1.00	1.00	0.60	-	-	1.00	1.00

- Case II = Summary of analysis and combinations that include seismic loads

  The ultimate design shall be used for seismic, with considering following load combinations:

  Comb 1 : $1.2D + E_v + E_h + L$

  Comb 2 : $0.9D – E_v + E_h$

4.6.1 Pile Loads or Pile Joint Reactions

Pile loads will be check under service condition and will be used in foundation analysis design. Pile loads from 3-D structural analysis result are summarized in the following table.

Table 4.1 Summary of Maximum Pile Loads – CSP 600

Joint Reactions							
CSP 0.60 m Thk 0.10 m							
Load Case	**Output Case**	**F1**	**F2**	**F3**	**M1**	**M2**	**M3**
Text	**Text**	**kN**	**kN**	**kN**	**kN-m**	**kN-m**	**kN-m**
Case Operational	Min	-5.42	-8.22	442.97	-4.68	-19.05	-0.11
	Max	7.77	1.02	989.42	39.37	30.51	0.03
Case Seismic	Min	-3.37	-24.66	114.39	-147.41	-17.40	-2.30
	Max	4.92	24.64	754.76	146.87	21.44	2.31

Table 4.2 Summary of Maximum Pile Loads – SPP 711

Joint Reactions							
SPP 0.711 m Thk 0.012 m							
Load Case	**Output Case**	**F1**	**F2**	**F3**	**M1**	**M2**	**M3**
Text	**Text**	**kN**	**kN**	**kN**	**kN-m**	**kN-m**	**kN-m**
Case Operational	Min	-10.71	-13.35	231.99	-3.75	-82.90	-0.20
	Max	1.75	0.36	926.35	127.48	18.85	4.33
Case Seismic	Min	-20.38	-16.01	73.49	-174.82	-198.99	-7.80
	Max	20.13	16.11	672.67	173.91	196.67	7.65

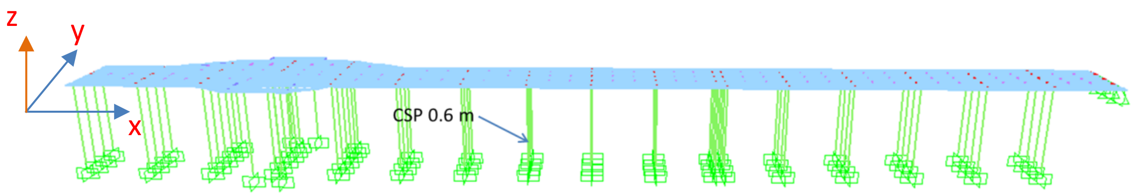
Directions of pile loads at support in SAP2000 are represented in F1, F2, F3, M1, M2 and M3 (F1 represent X-Direction, F2 represent Y-Direction and F3 represent Z-Direction), with following definitions:

F1 & F2 = Lateral load

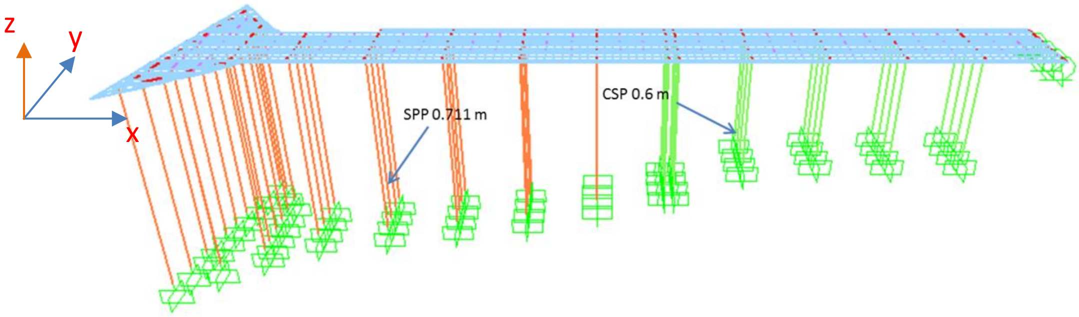
F3 = Axial load, with F3(+) = compression and F3(-) = tension

M1 & M2 = Moment

M3 = Torsion



Segment 1



Segment 2

Maximum pile loads in compression, tension, and lateral loads will be used for geotechnical and pile foundation design.

4.6.2 Element Forces – Pile Forces

Pile forces will be checked under service condition and summarized in the following table

Table 4.3 Summary of Maximum Pile Forces – CSP 600

Element Forces							
CSP 0.60 m Thk 0.10 m							
Load Case	**Output Case**	**P**	**V2**	**V3**	**T**	**M2**	**M3**
Text	**Text**	**kN**	**kN**	**kN**	**kN-m**	**kN-m**	**kN-m**
Case Operational	Min	-1009.98	-5.42	-1.02	-0.03	-39.37	-30.51
	Max	-417.08	10.49	8.22	0.11	30.30	67.71
Case Seismic	Min	-754.76	-3.37	-24.64	-2.31	-146.87	-23.30
	Max	-89.02	4.92	24.66	2.30	147.41	37.63

Table 4.4 Summary of Maximum Pile Forces – SPP 711

Element Forces							
SPP 0.711 m Thk 0.012 m							
Load Case	**Output Case**	**P**	**V2**	**V3**	**T**	**M2**	**M3**
Text	**Text**	**kN**	**kN**	**kN**	**kN-m**	**kN-m**	**kN-m**
Case Operational	Min	-1001.96	-10.71	-0.36	-4.33	-127.48	-51.40
	Max	-264.56	5.00	13.35	0.20	79.35	82.90
Case Seismic	Min	-672.67	-20.38	-16.11	-7.65	-173.91	-196.67
	Max	-42.99	20.13	16.01	7.80	174.82	198.99

Directions of pile element forces in SAP2000 are represented in P, V2, V3, T, M2, and M3, with following definitions:

- P = Axial force, with P(-) = compression and P(+) = tension
- V2 = Shear force in the 1-2 plane
- V3 = Shear force in the 1-3 plane
- T = Torsion (about the 1-axis)
- M2 = Bending moment in the 1-3 plane (about the 2-axis)
- M3 = Bending moment in the 1-2 plane (about the 3-axis)

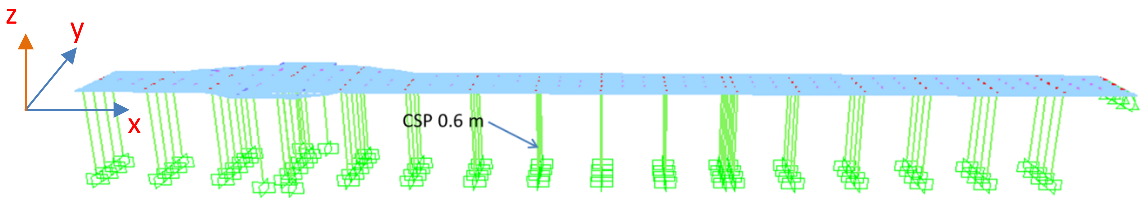
Checking the pile member force of concrete pile (CSP 600) capacity, as follows:

		Bending Moment Capacity			Allowable Axial Load		
Load Case	**Pile Type**	**Max Moment**	**Allowable Moment**	**Check**	**Max Axial Load**	**Allowable Axial Load**	**Check**
		kN-m	kN-m		kN	kN	
Operational Load	CSP 600	67.7	290	OK	1009.9	2295	OK
Seismic Load	CSP 600	147.4	580 (ult)	OK	754.8	2295	OK

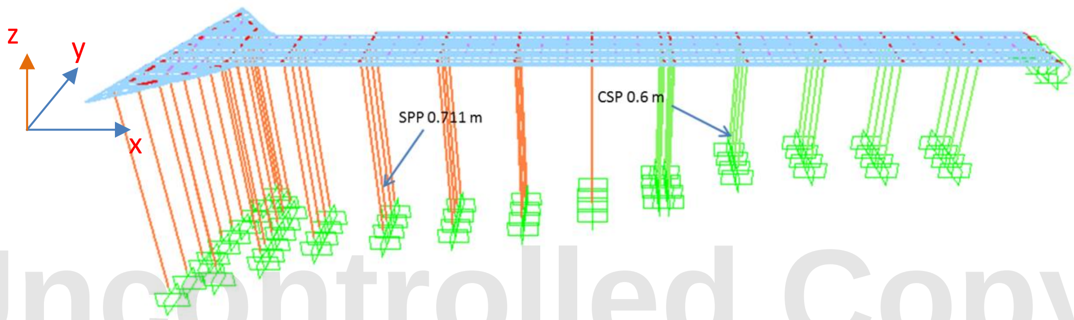
4.6.3 Structure Deflection

Deflection of trestle structure can be seen in the following table. Direction of deflection in SAP2000 represented in U1, U2 and U3. U1 represent X-Direction, U2 represent Y-Direction and U3 represent Z-Direction.

Maximum Deflection will be checked with Displacement limits refer to BS 6349-2:2019. According to BS, operational horizontal deflection limits for maritime structure is Height/300 with a maximum of 100 mm. With height is determined from the top of the structure to the fixity level. Vertical deflection on marine structure shall be limited to length/180 for cantilevers and Span/200 for spanning beams. Allowable displacement due to seismic load is taken 0.02*H, based on SNI 1726:2019.



Segment 1



Segment 2

Table 4.5 Summary of Maximum Deflection of Trestle Segment 1

Deflection Structure				
Load Case	**Output Case**	**U1**	**U2**	**U3**
Text	**Text**	**m**	**m**	**m**
Case Operational	Min	0.000	0.000	-0.002
	Max	0.000	0.004	0.000
Case Seismic	Min	-0.002	-0.021	-0.002
	Max	0.002	0.021	0.000

- Check horizontal deflection due to operational load

  Disp limit = Height/300

  = 13.4 m /300

  = 0.044 m

  Max. deflection = 0.004 m < 0.044 m… OK

- Check vertical deflection due to operational load

  Defl limit = Span/200

  = 9.0 m /200

  = 0.045 m

  Max. deflection = 0.002 m < 0.045 m… OK

- Check horizontal deflection due to seismic load

  Disp limit = 0.02*H

  = 0.02*13.4 m

  = 0.268 m

  Max. displacement = (0.021 m *2)/1 = 0.042 m < 0.268 m… OK

Table 4.6 Summary of Maximum Deflection of Trestle Segment 2

Deflection Structure				
Load Case	**Output Case**	**U1**	**U2**	**U3**
Text	**Text**	**m**	**m**	**m**
Case Operational	Min	-0.004	-0.002	-0.004
	Max	0.013	0.036	0.000
Case Seismic	Min	-0.041	-0.064	-0.003
	Max	0.041	0.062	0.000

- Check horizontal deflection due to operational load

  Disp limit = Height/300

  = 15.4 m /300

  = 0.051 m

  Max. deflection = 0.036 m < 0.051 m… OK
- Check vertical deflection due to operational load

  Defl limit = Span/200

  = 9.0 m /200

  = 0.045 m

  Max. deflection = 0.004 m < 0.045 m… OK
- Check horizontal deflection due to seismic load

  Disp limit = 0.02*H

  = 0.02*15.4 m

  = 0.308 m

  Max. displacement = (0.064 m *2)/1 = 0.128 m < 0.268 m… OK

4.6.4 Pile Stress Ratio

Steel pile design was calculated according to AISC-ASD for operational condition and AISC-LRFD for seismic condition, stress ratio is summarized in the following table:

Table 4.7 Summary of Maximum Pile Stress Ratio of SPP 711

Stress Ratio				
SPP 0.711 m Thk 0.012 m				
Design type	Ratio	Allowable Stress Ratio	Check	Design Code
Text	Unitless	Unitless	Text	Text
Case Operational	0.64	1.00	Ok	AISC-ASD
Case Seismic	0.55	1.00	Ok	AISC-LRFD

The pile stress ratio/ steel frame design is calculated by SAP2000 according to AISC ASD and AISC LRFD. This design considers the section property of pile, pile length, pile material, applied loads and load combination for Allowable Stress Design at operational condition and LRFD at Seismic condition.

4.7 Upper Structure Design

Upper structure/ superstructure will be presented at Detailed Engineering Design Stage. The design of upper structure include design of reinforcement, crack, and deflection of each element should consider the top deck layout, piping, utilities, and equipment above the structure. And currently, the process design is still in the preliminary or basic design stage.

APPENDIX - A PILE FOUNDATION DESIGN

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

1.1. GENERAL

This report will describe the analysis and design of trestle pile foundation.

1.2. UNIT

All units are in SI (system international) unit unless noted otherwise. This document will be in English.

2. BASIS OF FOUNDATION DESIGN

2.1. GEOTECHNICAL SCOPE DESIGN CRITERIA

The regulations and standards that are used as references in checking the pile foundation are as follows,

- SNI 8460:2017 – Geotechnical Design Requirements,
- FOUNDATION ANALYSIS AND DESIGN Fifth Edition Joseph E. Bowles, RE., S.E.,
- Principles of Foundation Engineering 7th Edition SI Units,
- The other equivalent standards.

2.2. SOIL DATA

Soil data to do bearing capacity and settlement analysis refer to bor log. The bor log is presented in the picture as follows.

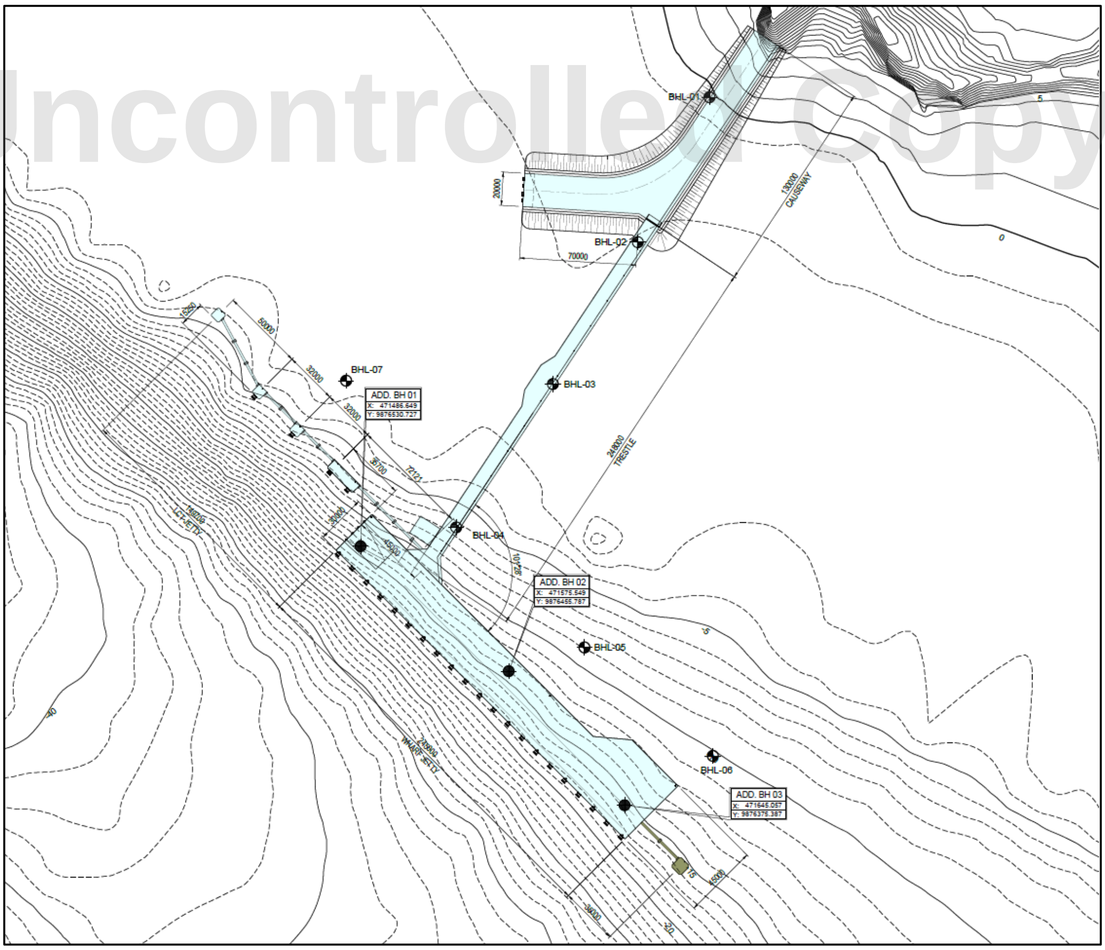
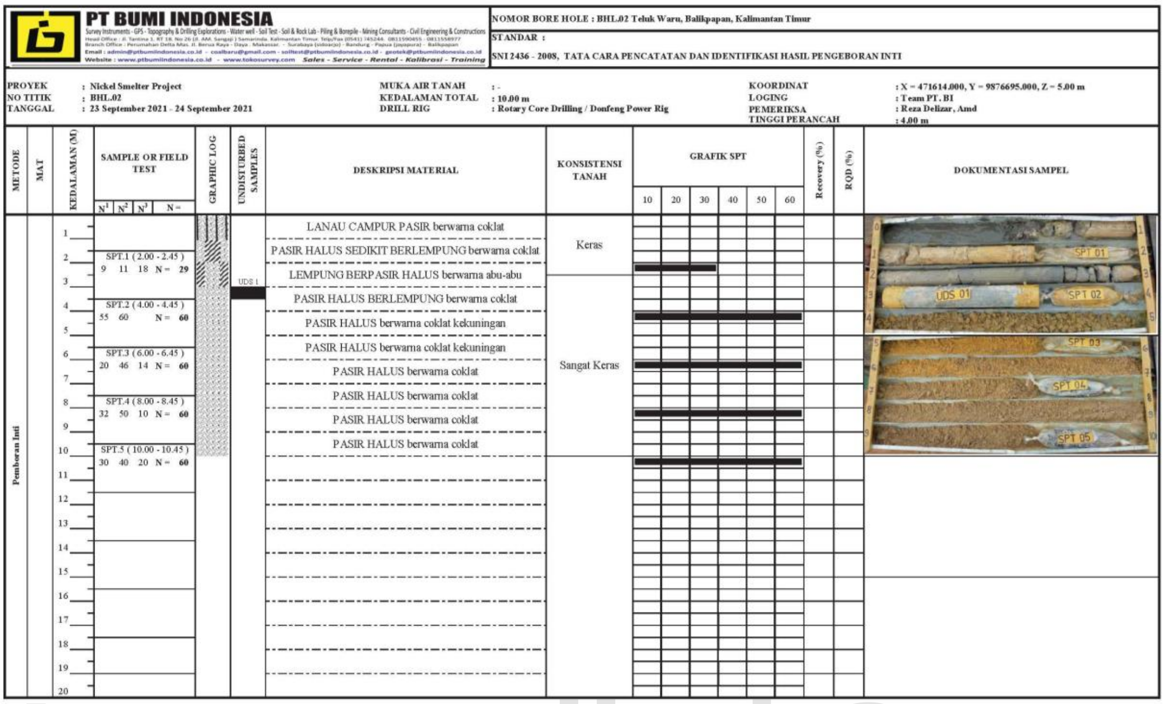


Figure 2-1 Layout Boring Log



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Survey Instruments - GPS - Topography & Drilling Explorations - Water well - Soil Test - Soil & Rock Lab - Piling & Borepile - Mining Consultants - Civil Engineering & Constructions

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NOMOR BORE HOLE : BHL.02 Teluk Waru, Balikpapan, Kalimantan Timur

STANDAR :

SNI 2436 - 2008, TATA CARA PENCATATAN DAN IDENTIFIKASI HASIL PENGEBORAN INTI

PROYEK	: Nickel Smelter Project	MUKA AIR TANAH	: -	KOORDINAT	: X = 471614.000, Y = 9876695.000, Z = 5.00 m
NO TITIK	: BHL.02	KEDALAMAN TOTAL	: 10.00 m	LOGING	: Team PT. BI
TANGGAL	: 23 September 2021 - 24 September 2021	DRILL RIG	: Rotary Core Drilling / Donfeng Power Rig	PEMERIKSA	: Reza Delizar, Amd
				TINGGI PERANCAH	: 4.00 m

METODE: Pemboran Inti

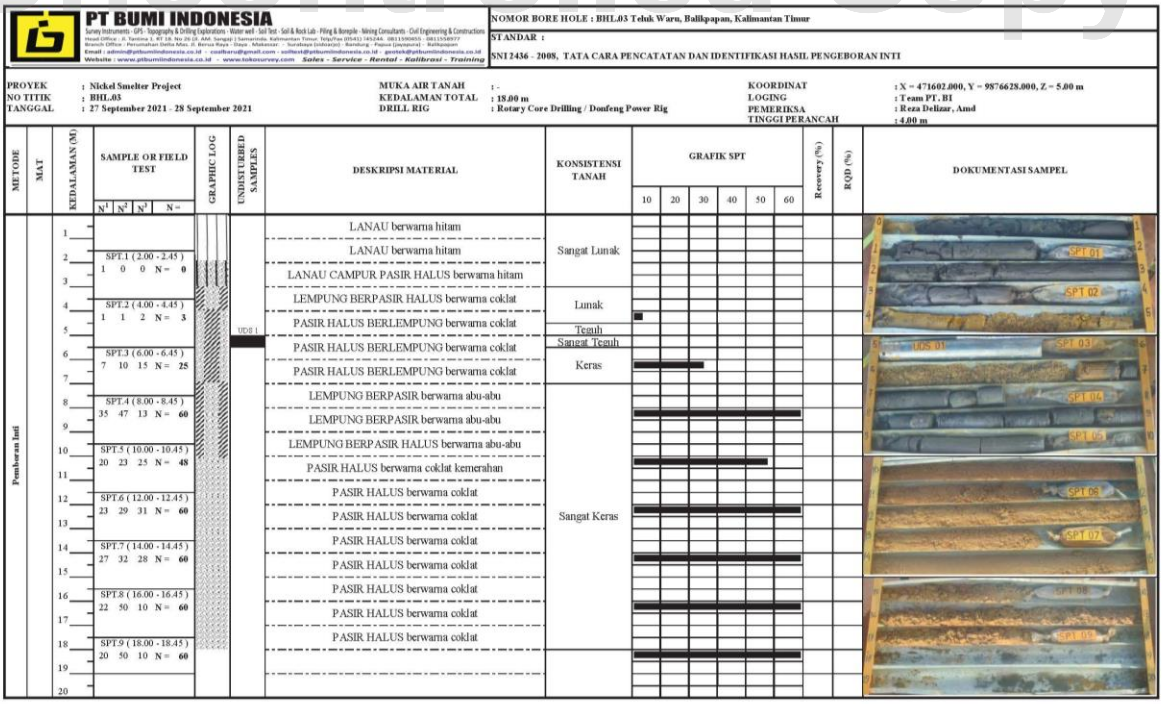
SAMPLE OR FIELD TEST	N^1	N^2	N^3	N =
SPT.1 (2.00 - 2.45)	9	11	18	29
SPT.2 (4.00 - 4.45)	55	60		60
SPT.3 (6.00 - 6.45)	20	46	14	60
SPT.4 (8.00 - 8.45)	32	50	10	60
SPT.5 (10.00 - 10.45)	30	40	20	60

UNDISTURBED SAMPLES: UDS 1

DESKRIPSI MATERIAL	KONSISTENSI TANAH
LANAU CAMPUR PASIR berwarna coklat	Keras
PASIR HALUS SEDIKIT BERLEMPUNG berwarna coklat	Keras
LEMPUNG BERPASIR HALUS berwarna abu-abu	Sangat Keras
PASIR HALUS BERLEMPUNG berwarna coklat	Sangat Keras
PASIR HALUS berwarna coklat kekuningan	Sangat Keras
PASIR HALUS berwarna coklat kekuningan	Sangat Keras
PASIR HALUS berwarna coklat	Sangat Keras
PASIR HALUS berwarna coklat	Sangat Keras
PASIR HALUS berwarna coklat	Sangat Keras
PASIR HALUS berwarna coklat	Sangat Keras

GRAFIK SPT: 10 20 30 40 50 60 — Recovery (%) — RQD (%) — DOKUMENTASI SAMPEL

Figure 2-2 Boring Log BHL-02



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NOMOR BORE HOLE : BHL.03 Teluk Waru, Balikpapan, Kalimantan Timur

STANDAR :

SNI 2436 - 2008, TATA CARA PENCATATAN DAN IDENTIFIKASI HASIL PENGEBORAN INTI

PROYEK	: Nickel Smelter Project	MUKA AIR TANAH	: -	KOORDINAT	: X = 471602.000, Y = 9876628.000, Z = 5.00 m
NO TITIK	: BHL.03	KEDALAMAN TOTAL	: 18.00 m	LOGING	: Team PT. BI
TANGGAL	: 27 September 2021 - 28 September 2021	DRILL RIG	: Rotary Core Drilling / Donfeng Power Rig	PEMERIKSA	: Reza Delizar, Amd
				TINGGI PERANCAH	: 4.00 m

METODE: Pemboran Inti

SAMPLE OR FIELD TEST	N^1	N^2	N^3	N =
SPT.1 (2.00 - 2.45)	1	0	0	0
SPT.2 (4.00 - 4.45)	1	1	2	3
SPT.3 (6.00 - 6.45)	7	10	15	25
SPT.4 (8.00 - 8.45)	35	47	13	60
SPT.5 (10.00 - 10.45)	20	23	25	48
SPT.6 (12.00 - 12.45)	23	29	31	60
SPT.7 (14.00 - 14.45)	27	32	28	60
SPT.8 (16.00 - 16.45)	22	50	10	60
SPT.9 (18.00 - 18.45)	20	50	10	60

UNDISTURBED SAMPLES: UDS 1

DESKRIPSI MATERIAL	KONSISTENSI TANAH
LANAU berwarna hitam	Sangat Lunak
LANAU berwarna hitam	Sangat Lunak
LANAU CAMPUR PASIR HALUS berwarna hitam	Sangat Lunak
LEMPUNG BERPASIR HALUS berwarna coklat	Lunak
PASIR HALUS BERLEMPUNG berwarna coklat	Lunak / Teguh
PASIR HALUS BERLEMPUNG berwarna coklat	Sangat Teguh / Keras
PASIR HALUS BERLEMPUNG berwarna coklat	Keras
LEMPUNG BERPASIR berwarna abu-abu	Sangat Keras
LEMPUNG BERPASIR berwarna abu-abu	Sangat Keras
LEMPUNG BERPASIR HALUS berwarna abu-abu	Sangat Keras
PASIR HALUS berwarna coklat kemerahan	Sangat Keras
PASIR HALUS berwarna coklat	Sangat Keras
PASIR HALUS berwarna coklat	Sangat Keras
PASIR HALUS berwarna coklat	Sangat Keras
PASIR HALUS berwarna coklat	Sangat Keras
PASIR HALUS berwarna coklat	Sangat Keras
PASIR HALUS berwarna coklat	Sangat Keras
PASIR HALUS berwarna coklat	Sangat Keras

GRAFIK SPT: 10 20 30 40 50 60 — Recovery (%) — RQD (%) — DOKUMENTASI SAMPEL

Figure 2-3 Boring Log BHL-03

APPENDIX – A PILE FOUNDATION DESIGN

PT BUMI INDONESIA Survey Instruments - GPS - Topography & Drilling Explorations - Water well - Soil Test - Soil & Rock Lab - Piling & Borepile - Mining Consultants - Civil Engineering & Constructions Head Office : Jl. Tantina 1. RT 18. No 26 (Jl. AM. Sangaji) Samarinda. Kalimantan Timur. Telp/Fax (0541) 745244. 0811590455 - 0811558977 Branch Office : Perumahan Delta Mas. Jl. Berua Raya - Daya . Makassar. - Surabaya (sidoarjo) - Bandung - Papua (jayapura) - Balikpapan Email : admin@ptbumiindonesia.co.id - coalbaru@gmail.com - soiltest@ptbumiindonesia.co.id - geotek@ptbumiindonesia.co.id Website : www.ptbumiindonesia.co.id - www.tokosurvey.com Sales - Service - Rental - Kalibrasi - Training	NOMOR BORE HOLE : BHL.04 Teluk Waru, Balikpapan, Kalimantan Timur STANDAR : SNI 2436 - 2008, TATA CARA PENCATATAN DAN IDENTIFIKASI HASIL PENGEBORAN INTI

PROYEK	: Nickel Smelter Project	MUKA AIR TANAH	: -	KOORDINAT	: X = 471544.000, Y = 9876542.000, Z = 5.00 m
NO TITIK	: BHL.04	KEDALAMAN TOTAL	: 20.00 m	LOGING	: Team PT. BI
TANGGAL	: 07 Oktober 2021 - 08 Oktober 2021	DRILL RIG	: Rotary Core Drilling / Donfeng Power Rig	PEMERIKSA	: Reza Delizar, Amd
				TINGGI PERANCAH	: 6.00 m

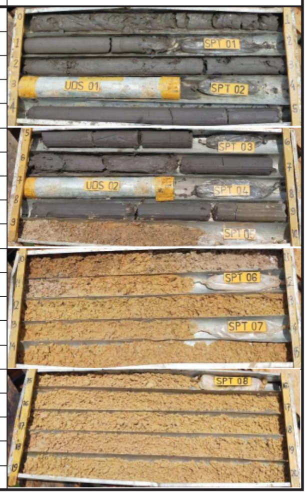
METODE	MAT	KEDALAMAN (M)	SAMPLE OR FIELD TEST (N^1 N^2 N^3 N =)	GRAPHIC LOG	UNDISTURBED SAMPLES	DESKRIPSI MATERIAL	KONSISTENSI TANAH	GRAFIK SPT (10 20 30 40 50 60)	Recovery (%)	RQD (%)	DOKUMENTASI SAMPEL
Pemboran Inti		1				LANAU CAMPUR PASIR berwarna abu-abu					
		2				LANAU CAMPUR PASIR berwarna abu-abu					
		3	SPT.1 (2.00 - 2.45) 1 0 0 N = 0		UDS 1	LANAU CAMPUR PASIR berwarna abu-abu	Sangat Lunak				
		4				LEMPUNG CAMPUR PASIR berwarna abu-abu					
		5	SPT.2 (4.00 - 4.45) 1 0 0 N = 0			LEMPUNG CAMPUR PASIR berwarna abu-abu					
		6				LEMPUNG BERPASIR berwarna abu-abu					
		7	SPT.3 (6.00 - 6.45) 1 1 2 N = 3		UDS 2	LEMPUNG BERPASIR berwarna abu-abu	Lunak				
		8				LEMPUNG BERPASIR berwarna abu-abu	Teguh				
		9	SPT.4 (8.00 - 8.45) 3 3 5 N = 8			LEMPUNG BERPASIR berwarna abu-abu	Sangat Teguh				
		10				PASIR HALUS berwarna coklat	Keras				
		11	SPT.5 (10.00 - 10.45) 60 > > N = 60			PASIR HALUS berwarna coklat keabu-abuan					
		12				PASIR HALUS berwarna coklat kekuningan					
		13	SPT.6 (12.00 - 12.45) 48 60 N = 60			PASIR HALUS berwarna coklat kekuningan					
		14				PASIR HALUS berwarna coklat kekuningan					
		15	SPT.7 (14.00 - 14.45) 30 43 17 N = 60			PASIR HALUS berwarna coklat kekuningan	Sangat Keras				
		16				PASIR HALUS berwarna coklat keabu-abuan					
		17	SPT.8 (16.00 - 16.45) 53 60 N = 60			PASIR HALUS berwarna coklat keabu-abuan					
		18				PASIR HALUS berwarna coklat keabu-abuan					
		19	SPT.9 (18.00 - 18.45) 40 60 N = 60			PASIR HALUS berwarna coklat keabu-abuan					
		20	SPT.10 (20.00 - 20.45) 50 60 N = 60			PASIR HALUS berwarna coklat keabu-abuan					

Figure 2-4 Boring Log BHL-04

2.3. FOUNDATION ANALYSIS BASED ON N-SPT CORRELATIONS

This chapter explains the analysis of the foundation include bearing capacity and settlement prediction. The analysis based on site geotechnical investigation that has been done.

2.3.1. Single Pile Axial Bearing Capacity

The ultimate axial bearing capacity of driven spun pile was obtained by a simple equation as the sum of the end bearing and the skin friction resistance of pile, as follow:

Qu = Qp + Qs

where:

Qu = the ultimate pile capacity

Qp = the ultimate end bearing capacity

Qs = the ultimate skin friction resistance

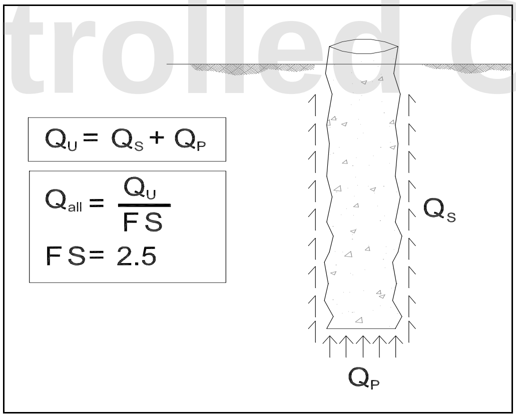


Figure 2-5 Pile Axial Bearing Capacity

2.3.2. Skin Friction Resistance

The ultimate skin friction resistance of a driven pile in c-ϕ soil can be calculated with the following equation:

Qs = Qsc + Qsϕ

where:

Qs = the ultimate skin friction resistance

Qsc = cohesion contribution of soil, c (for clay soil)

Qsϕ = soil friction angle contribution, ϕ (for sand soil)

2.3.3. Cohesion Distribution of Soil

Generally, cohesion contribution of soil for the ultimate skin friction was obtained by the following formula:

$$Qsc = \sum_{i-1}^{n} \alpha\, c_{u-i}\, I_i . p$$

where:

α = adhesion factor

Cu-i = undrained soil cohesion at layer-i

li = the length of pile at layer-I

p = pile perimeter

The value of adhesion factor, α, especially for driven pile, can be obtained with the API method as follow:

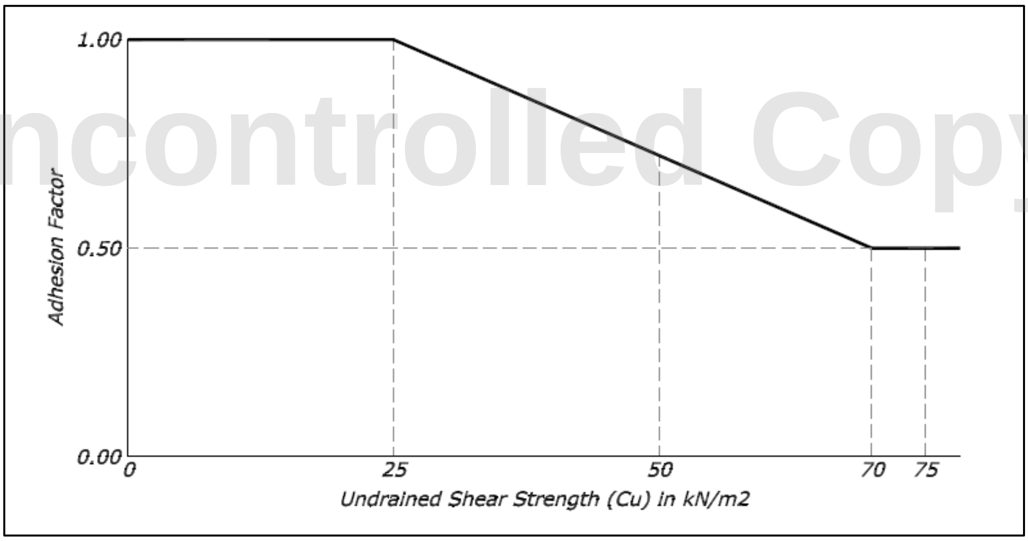


Figure 2-6 Adhesion Factors vs Undrained Shearing Resistance for Driven Piles

2.3.4. Contribution of Internal Friction in Soil, ϕ

The contribution interval friction angle of soil, ϕ for the ultimate skin friction resistance could be obtained by the following formula,

$$Qs\phi = \sum_{i-1}^{n} f_i . I_i . p$$

Where,

Qsφ = contribution of internal friction angle of soil, ϕ for ultimate skin friction resistance

fi = Ksi.σV-i.tan (δ)

Ks = coefficient of horizontal soil stress at layer-i

σV-i = effective vertical stress at middle of layer-i

φ = angle of wall friction at layer –i

li = length of pile segment along layer-i

p = perimeter of pile

A value of K 0.8 is recommended for open-ended pipe piles that are driven unplugged, for loadings in both tension and compression. A value of k of 1.0 is recommended for full displacement piles. In the absence of data on δ, Table 2-1 was selected as guidelines only for siliceous sand.

Table 2-1 Value of the Friction Angle for Certain Soil

Soil	δ, degrees	Limiting f, kips/ft² (kPa)
very loose to medium, sand to silt	15	1.0 (47.8)
loose to dense, sand to silt	20	1.4 (67.0)
medium to dense, sand to sand-silt	25	1.7 (83.1)
dense to very dense, sand to sand-silt	30	2.0 (95.5)
dense to very dense, gravel to sand	35	2.4 (114.8)

Meyerhof has also indicated that the average unit friction resistance for driven high-displacement piles in sand can be obtained from the average N-SPT value as,

Qu = 0.2 N. As

N = Mean N value for the total embedded length of the pile

2.3.5. End Bearing Capacity

In general, the ultimate end bearing capacity of driven pile that penetrated into c-ϕ soils could be expressed as :

$$Qp = Ap\ (c\ Nc + q\ Nq)$$

Where,

Qp = ultimate end bearing capacity

Ap = area of pile tip

q’ = effective vertical stress at the level of pile tip

Nc*, Nq* = the bearing capacity factors

2.3.6. End Bearing in Cohesive Soil

The API recommendation in equal form is as follows, along with a suggestion for modifying the value of c :

$$Qp = qAp$$

$$q = 9c$$

Where,

Qp = axial load capacity in end bearing

q = unit bearing resistance

c = undrained shear strength at tip of pile, usually taken as the average over a distance of 2 diameters below the tip of the pile, and

Ap = cross-sections area of tip of pile

2.3.7. End Bearing in Cohesionless Soil

For end bearing in cohesionless soils, API recommends the following,

$$q = \alpha' Nq$$

Where,

α' = effective overburden pressure at pile tip, and

Nq = bearing capacity factor

For siliceous soil, Table 2-2 was recommended as guidelines.

Table 2-2 Value of Capacity for Certain

Soil	Nq	Limiting q	
		Kips/ft^2	MPa
Very loose to medium, sand to silt	8	40	1.9
Loose to dense, sand to silt	12	60	2.9
Medium to dense, sand to sand silt	20	100	4.8
Dense to very dense, sand to sand-silt	40	200	9.6
Dense to very dense, gravel to sand	50	250	12.0

On the basis of field observations, Meyerhof (1976) also suggested that the ultimate point resistance q_p in a homogeneous granular soil may be obtained from standard penetration numbers as,

$$q_p = 0.4 p_a N_{60} \left(\frac{L}{D}\right)$$

Where,

N_{60} = the average value of the standard penetration number near the pile point (about 10*D* above and 4*D* below the pile point)

p_a = atmospheric pressure (≈ 100 kN/m^2 or 2000 lb/ft^2)

2.3.8. Pile Ultimate Bearing Capacity

Pile ultimate bearing capacity is ultimate bearing capacity divided by safety factor, can be written with the following equation:

$$Qall = \frac{Qult}{SF}$$

In general, the safety factor that commonly used is between 2-4 for the operational conditions. Based on SNI Geotechnical Design the minimum safety factor value for deep foundation is 2.5 for deep foundation capacity.

The value of the safety factor depends on the reliability of the static analysis method that used based on the following condition:

- The accuracy of soil parameters used in the design.
- The uniform of the soil layer.
- Effect and consistency of pile installation method.
- The quality of construction supervisor.
- Pile investigation with Static Loading Test or Pile Driving Analysis (PDA) test.

2.3.9. Pile Test

Pile tests need to be carried out at the beginning of driving before continuing to drive at other points. This is necessary because of the varying soil conditions, therefore, to find out the actual of bearing capacity of the soil, it is necessary to do a pile test.

3. FOUNDATION DESIGN FOR TRESTLE SECTION 1

3.1. PILE LOAD SERVICE CONDITIONS BHL-02

Joint reaction result from structure model of Trestle using driven pile CSP 600 T100 mm, can be seen on the table below.

Table 3-1 Summary of Pile Load for Trestle Section 1

Joint Reactions							
CSP 0.60 m Thk 0.10 m							
Load Case	**Output Case**	**F1**	**F2**	**F3**	**M1**	**M2**	**M3**
Text	**Text**	**kN**	**kN**	**kN**	**kN-m**	**kN-m**	**kN-m**
Case Operational	Min	-5.42	-8.22	442.97	-4.68	-19.05	-0.11
	Max	7.77	1.02	989.42	39.37	30.51	0.03
Case Seismic	Min	-3.37	-24.66	114.39	-147.41	-17.40	-2.30
	Max	4.92	24.64	754.76	146.87	21.44	2.31

Summary of the geotechnical analysis is as follows:

- Axial Compression, Pc = 989.42 kN
- Axial Tensile, Pt = 0 kN
- Lateral, H = 8.22 kN

Pile bearing capacity analysis using load from structural analysis result. The result of pile bearing capacity analysis will explained below.

Detail of pile and bor log reference is as follows:

- Pile Type = CSP 600 T100 mm
- Embedded Pile Length = 12 m
- Seabed Elevation = -5 m
- Cut Off Elevation = +3.5 m
- Total Pile Length = 12 + 5 + 3.5 m
  = 21 m
- Reference Bor Log = BHL-02

3.1.1. Check Pile Bearing Capacity

The value of axial compression and axial tension of pile based on borlog BHL-02 (Service Condition) is as follows:

DRIVEN CONCRETE SPUN PILE FOUNDATION CARRYING CAPACITY
BASED ON N (SPT) VALUE

PROJECT	: Project di Teluk Waru
LOCATION	: Balikpapan, Kalimantan Timur
BORING NO.	: BHL-02

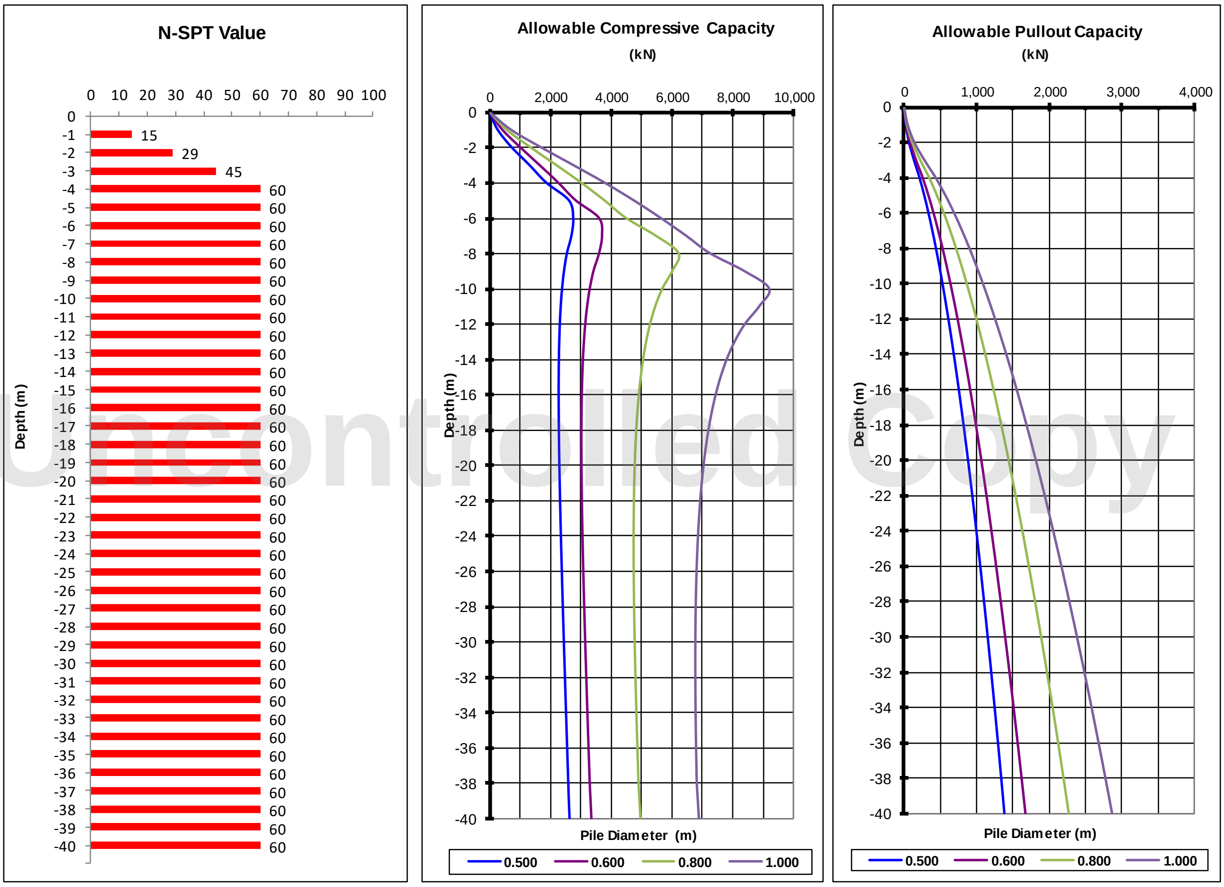


Figure 3-1 Pile Bearing Capacity for Trestle based on BHL-02

Axial Compression Capacity (CSP 600 T100 mm)

P max	= 989.42	kN		
Pall,c	= 3160.20	kN (based on BHL-02) (SF = 2.5)		
P	= 989.42	<	3160.20	OK!

Axial Tensile Capacity (CSP 600 T100 mm)

P max	= 0	kN		
Pall,t	= 739.66		kN (based on BHL-02) (SF = 2.5)	
P	= 0	<	739.66	OK!

3.1.2. Check Lateral Pile Bearing Capacity

Service Condition

Pile Type CSP 600 T100 mm

Lateral bearing capacity for vertical pile CSP 600 T100 mm is as follows:

Lateral = 8.22 kN

Lateral load bearing capacity analysis using AllPile computer program (CivilTech Software, U.S). Based on the calculation result, the value of maximum lateral deflection estimation of pile CSP 600 T100 mm (Service Condition), is 0.019 cm. The limitation of pile maximum deflection is 1" or 2.54 cm [8460:2017 SNI GEOTEKNIK chapter 190 and TPKB, chapter 19], so deflection of pile still below the permitted limit (0.019 cm < 2.54 cm, OK!).

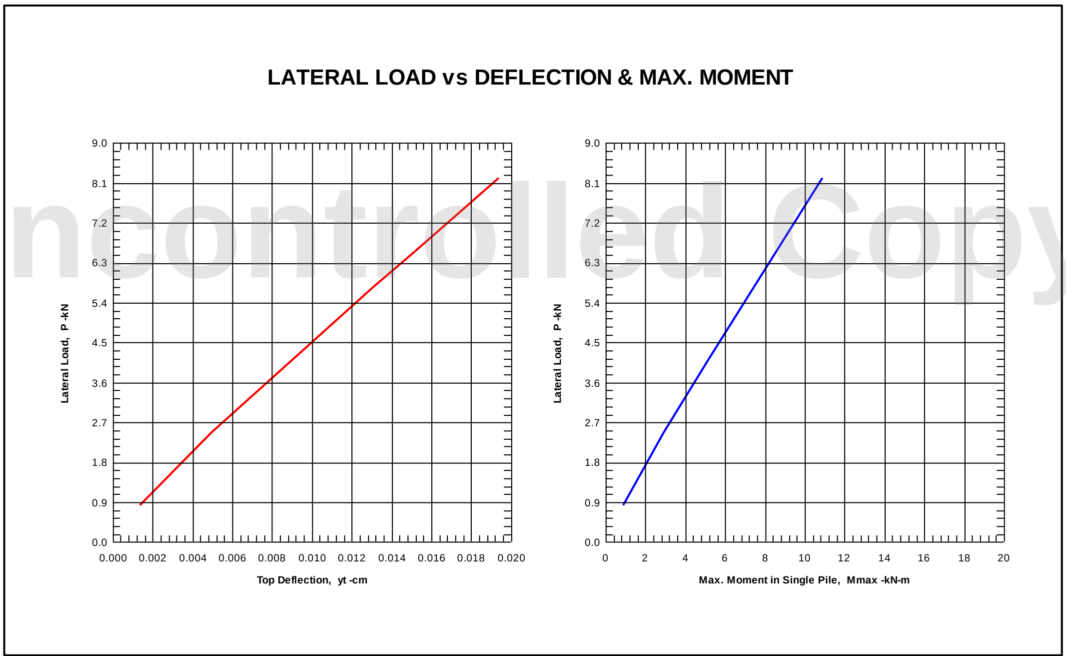


Figure 3-2 Lateral Bearing Capacity of Pile CSP 600 T100 mm for Trestle based on BHL-02

3.1.3. Settlement of Pile

The maximum settlement estimation of pile CSP 600 T100 mm is 0.386 cm. The limitation of pile maximum settlement is 1" or 2.54 cm [8460:2017 SNI GEOTEKNIK chapter 189 and TPKB, chapter 18], so settlement of pile still below the permitted limit (0.386 cm < 2.54 cm, OK!).

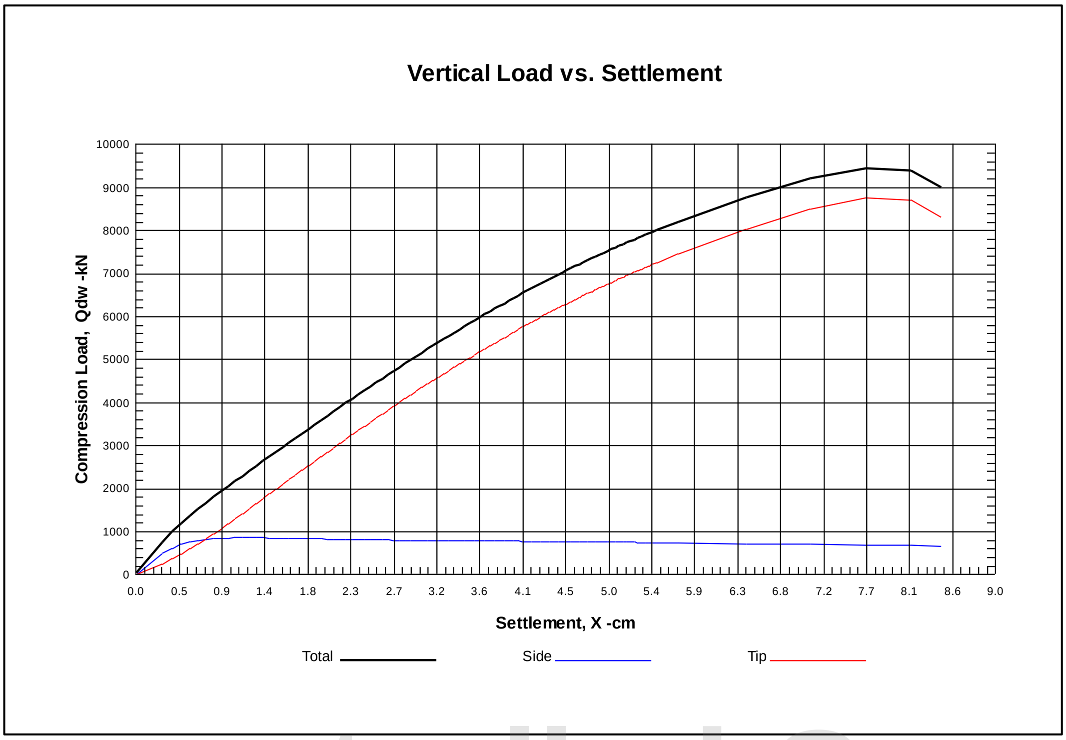


Figure 3-3 Vertical Load vs Total Settlement of Pile CSP 600 T100 mm for Trestle based on BHL-02

3.2. PILE LOAD SEISMIC CONDITIONS BHL-02

Joint reaction result from structure model of Trestle using driven pile CSP 600 T100 mm, can be seen on the table below.

Table 3-2 Summary of Pile Load for Trestle Section 1

Joint Reactions							
CSP 0.60 m Thk 0.10 m							
Load Case	**Output Case**	**F1**	**F2**	**F3**	**M1**	**M2**	**M3**
Text	**Text**	**kN**	**kN**	**kN**	**kN-m**	**kN-m**	**kN-m**
Case Operational	Min	-5.42	-8.22	442.97	-4.68	-19.05	-0.11
	Max	7.77	1.02	989.42	39.37	30.51	0.03
Case Seismic	Min	-3.37	-24.66	114.39	-147.41	-17.40	-2.30
	Max	4.92	24.64	754.76	146.87	21.44	2.31

Summary of the geotechnical analysis is as follows:

- Axial Compression, Pc = 754.76 kN
- Axial Tensile, Pt = 0 kN
- Lateral, H = 24.66 kN

Pile bearing capacity analysis using load from structural analysis result. The result of pile bearing capacity analysis will explained below.

Detail of pile and bor log reference is as follows:

- Pile Type = CSP 600 T100 mm
- Embedded Pile Length = 12 m
- Seabed Elevation = -5 m
- Cut Off Elevation = +3.5 m
- Total Pile Length = 12 + 5 + 3.5 m
  = 21 m
- Reference Bor Log = BHL-02

3.2.1. Check Pile Bearing Capacity

The value of axial compression and axial tension of pile based on borlog BHL-02 (Seismic Condition) is as follows:

DRIVEN CONCRETE SPUN PILE FOUNDATION CARRYING CAPACITY
BASED ON N (SPT) VALUE

PROJECT	: Project di Teluk Waru
LOCATION	: Balikpapan, Kalimantan Timur
BORING NO.	: BHL-02

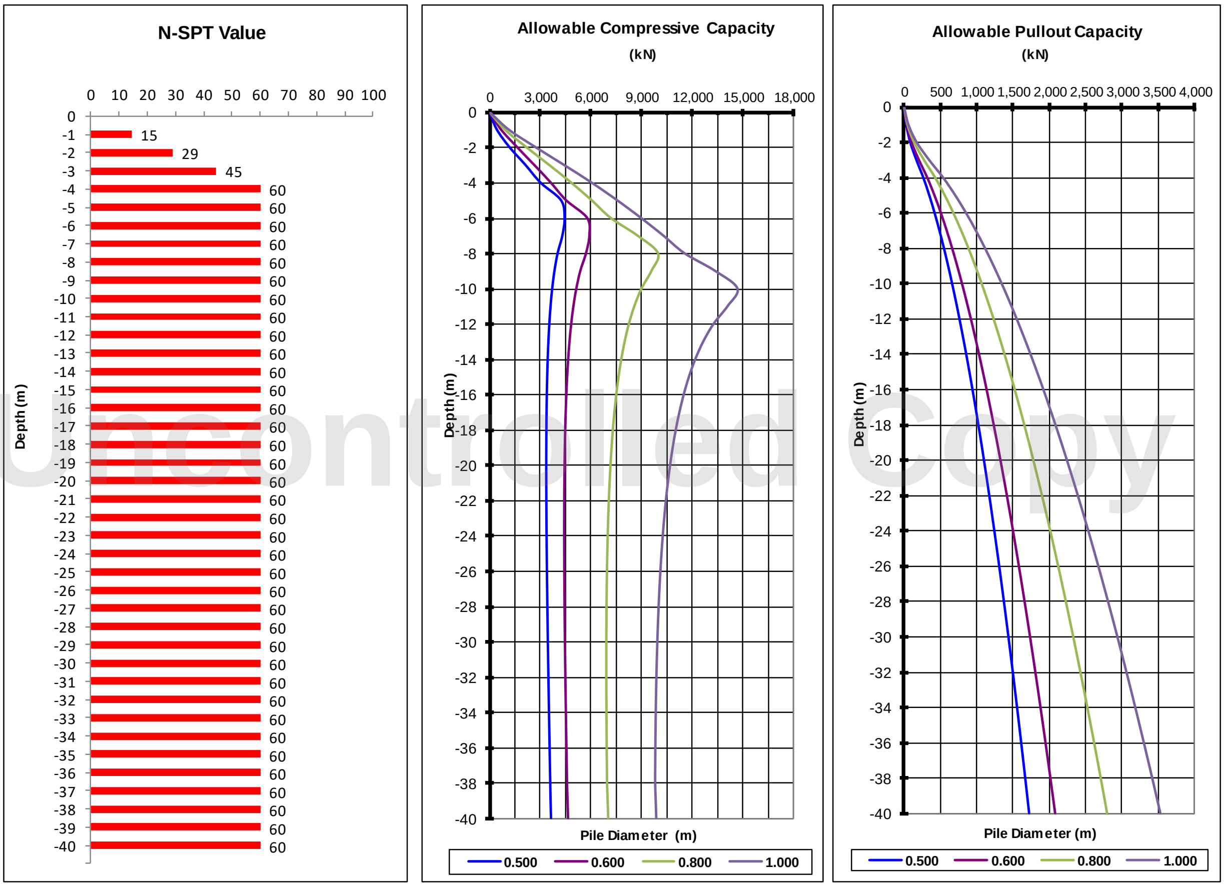


Figure 3-4 Pile Bearing Capacity for Trestle based on BHL-02

Axial Compression Capacity (CSP 600 T100 mm)

P max	= 754.76	kN		
Pall,c	= 4842.44	kN (based on BHL-02) (SF = 1.5)		
P	= 754.76	<	4842.44	OK!

Axial Tensile Capacity (CSP 600 T100 mm)

P max	= 0	kN		
Pall,t	= 917.98		kN (based on BHL-02) (SF = 2)	
P	= 0	<	917.98	OK!

3.2.2. Check Lateral Pile Bearing Capacity

Seismic Condition

Pile Type CSP 600 T100 mm

Lateral bearing capacity for vertical pile CSP 600 T100 mm is as follows:

Lateral = 24.66 kN

Lateral load bearing capacity analysis using AllPile computer program (CivilTech Software, U.S). Based on the calculation result, the value of maximum lateral deflection estimation of pile CSP 600 T100 mm (Seismic Condition), is 0.024 cm. The limitation of pile maximum deflection is 1” or 2.54 cm [8460:2017 SNI GEOTEKNIK chapter 190 and TPKB, chapter 19], so deflection of pile still below the permitted limit (0.024 cm < 2.54 cm, OK!).

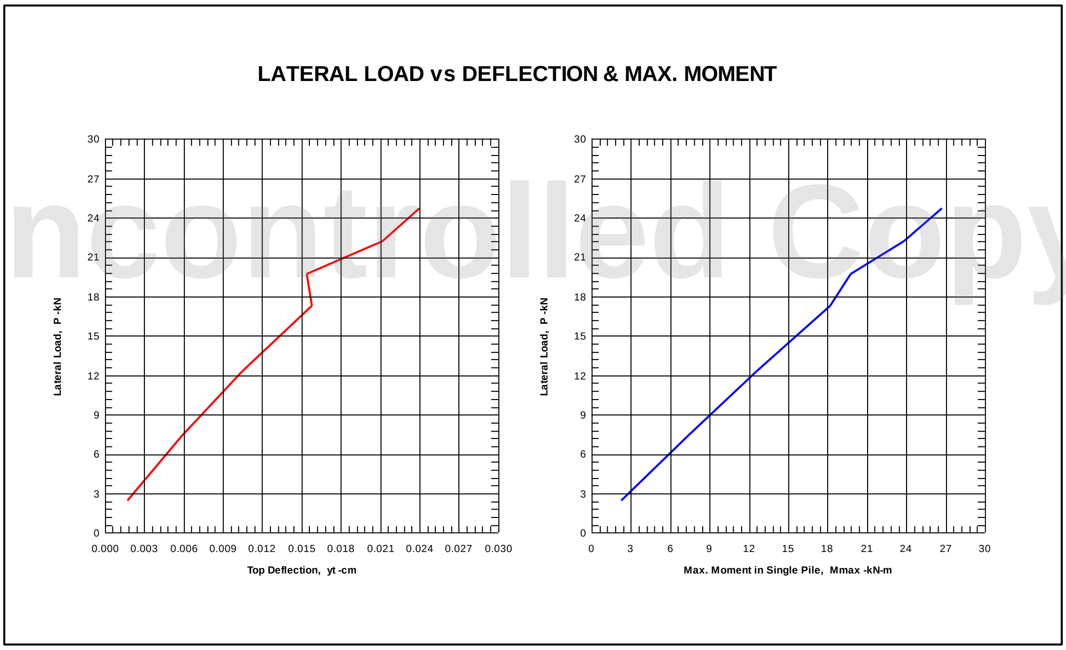


Figure 3-5 Lateral Bearing Capacity of Pile CSP 600 T100 mm for Trestle based on BHL-02

3.2.3. Settlement of Pile

The maximum settlement estimation of pile CSP 600 T100 mm is 0.173 cm. The limitation of pile maximum settlement is 1” or 2.54 cm [8460:2017 SNI GEOTEKNIK chapter 189 and TPKB, chapter 18], so settlement of pile still below the permitted limit (0.173 cm < 2.54 cm, OK!).

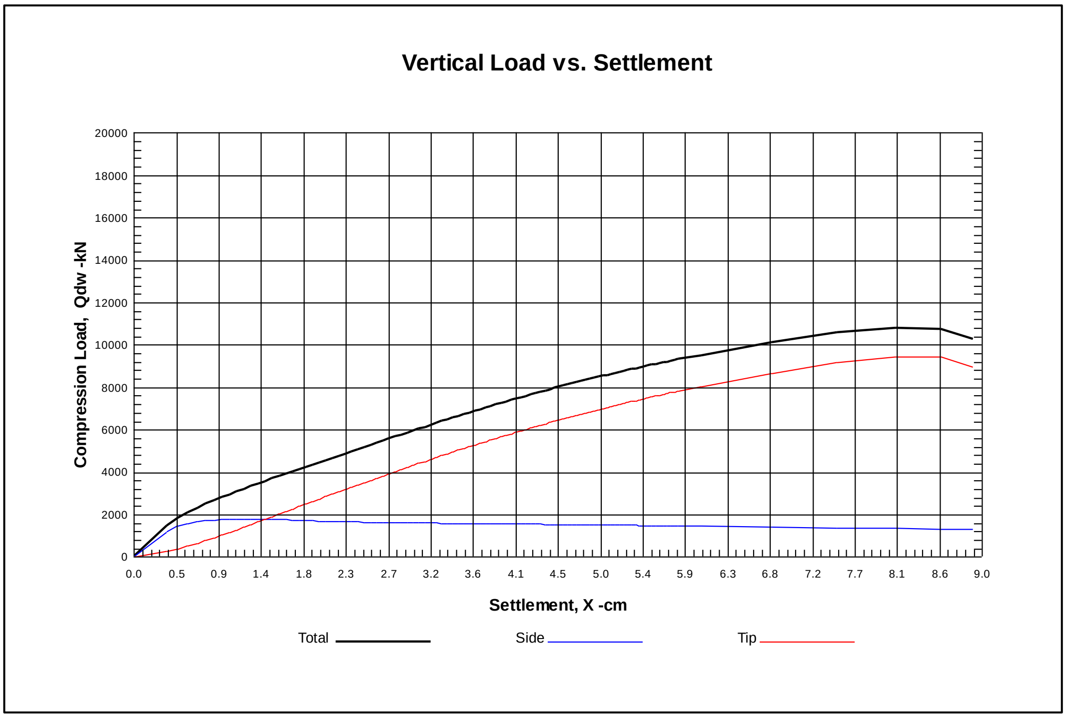


Figure 3-6 Vertical Load vs Total Settlement of Pile CSP 600 T100 mm for Trestle based on BHL-02

3.3. PILE LOAD SERVICE CONDITIONS BHL-03

Joint reaction result from structure model of Trestle using driven pile CSP 600 T100 mm, can be seen on the table below.

Table 3-3 Summary of Pile Load for Trestle Section 1

Joint Reactions							
CSP 0.60 m Thk 0.10 m							
Load Case	**Output Case**	**F1**	**F2**	**F3**	**M1**	**M2**	**M3**
Text	**Text**	**kN**	**kN**	**kN**	**kN-m**	**kN-m**	**kN-m**
Case Operational	Min	-5.42	-8.22	442.97	-4.68	-19.05	-0.11
	Max	7.77	1.02	989.42	39.37	30.51	0.03
Case Seismic	Min	-3.37	-24.66	114.39	-147.41	-17.40	-2.30
	Max	4.92	24.64	754.76	146.87	21.44	2.31

Summary of the geotechnical analysis is as follows:

- Axial Compression, Pc = 989.42 kN
- Axial Tensile, Pt = 0 kN
- Lateral, H = 8.22 kN

Pile bearing capacity analysis using load from structural analysis result. The result of pile bearing capacity analysis will explained below.

Detail of pile and bor log reference is as follows:

- Pile Type = CSP 600 T100 mm
- Embedded Pile Length = 12 m
- Seabed Elevation = -5 m
- Cut Off Elevation = +3.5 m
- Total Pile Length = 12 + 5 + 3.5 m
  = 21 m
- Reference Bor Log = BHL-03

3.3.1. Check Pile Bearing Capacity

The value of axial compression and axial tension of pile based on borlog BHL-03 (Service Condition) is as follows:

DRIVEN CONCRETE SPUN PILE FOUNDATION CARRYING CAPACITY

BASED ON N (SPT) VALUE

PROJECT	: Project di Teluk Waru
LOCATION	: Balikpapan, Kalimantan Timur
BORING NO.	: BHL-03

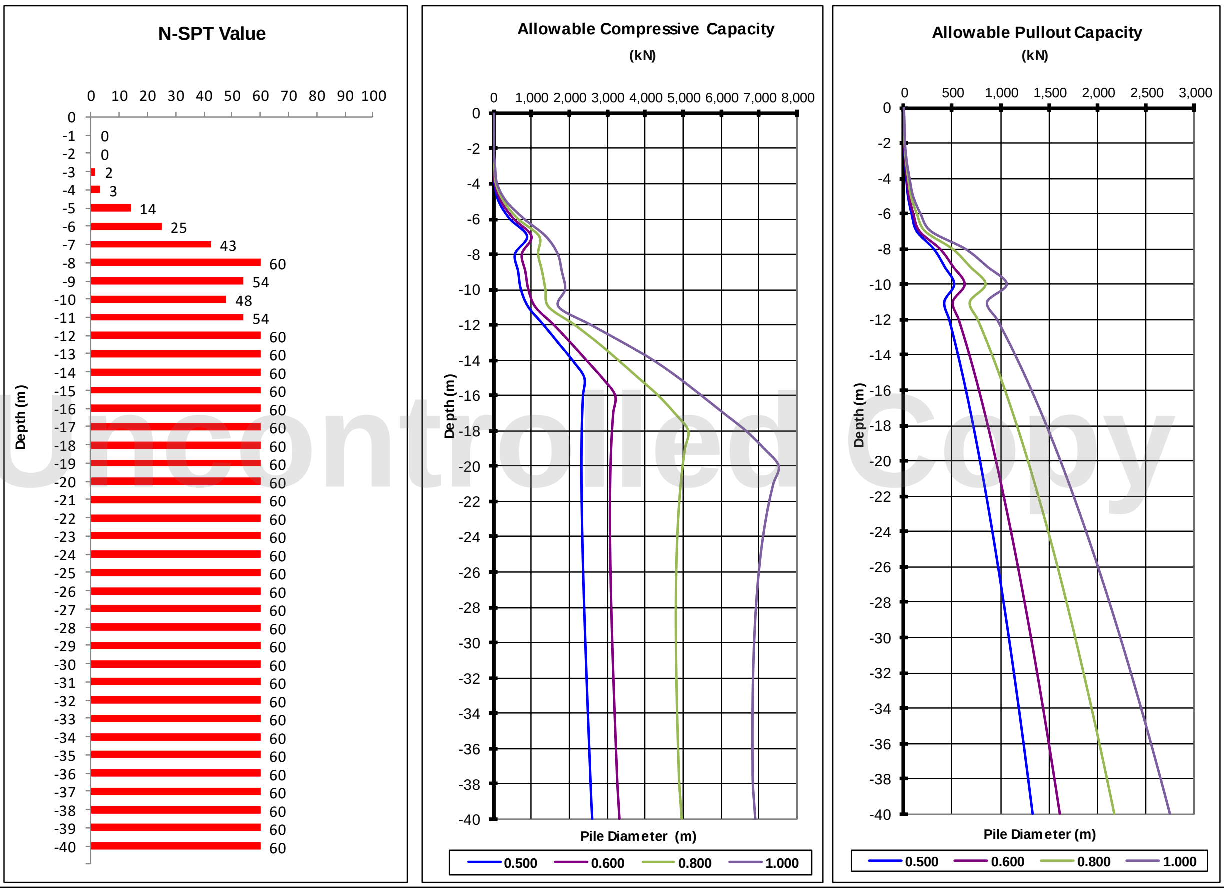


Figure 3-7 Pile Bearing Capacity for Trestle based on BHL-03

Axial Compression Capacity (CSP 600 T100 mm)

P max	= 989.42	kN		
Pall,c	= 1585.59	kN (based on BHL-03) (SF = 2.5)		
P	= 989.42	<	1585.59	OK!

Axial Tensile Capacity (CSP 600 T100 mm)

P max	= 0	kN		
Pall,t	= 565.16		kN (based on BHL-03) (SF = 2.5)	
P	= 0	<	565.16	OK!

3.3.2. Check Lateral Pile Bearing Capacity

Service Condition

Pile Type CSP 600 T100 mm

Lateral bearing capacity for vertical pile CSP 600 T100 mm is as follows:

Lateral = 8.22 kN

Lateral load bearing capacity analysis using AllPile computer program (CivilTech Software, U.S). Based on the calculation result, the value of maximum lateral deflection estimation of pile CSP 600 T100 mm (Service Condition), is 0.051 cm. The limitation of pile maximum deflection is 1” or 2.54 cm [8460:2017 SNI GEOTEKNIK chapter 190 and TPKB, chapter 19], so deflection of pile still below the permitted limit (0.051 cm < 2.54 cm, OK!).

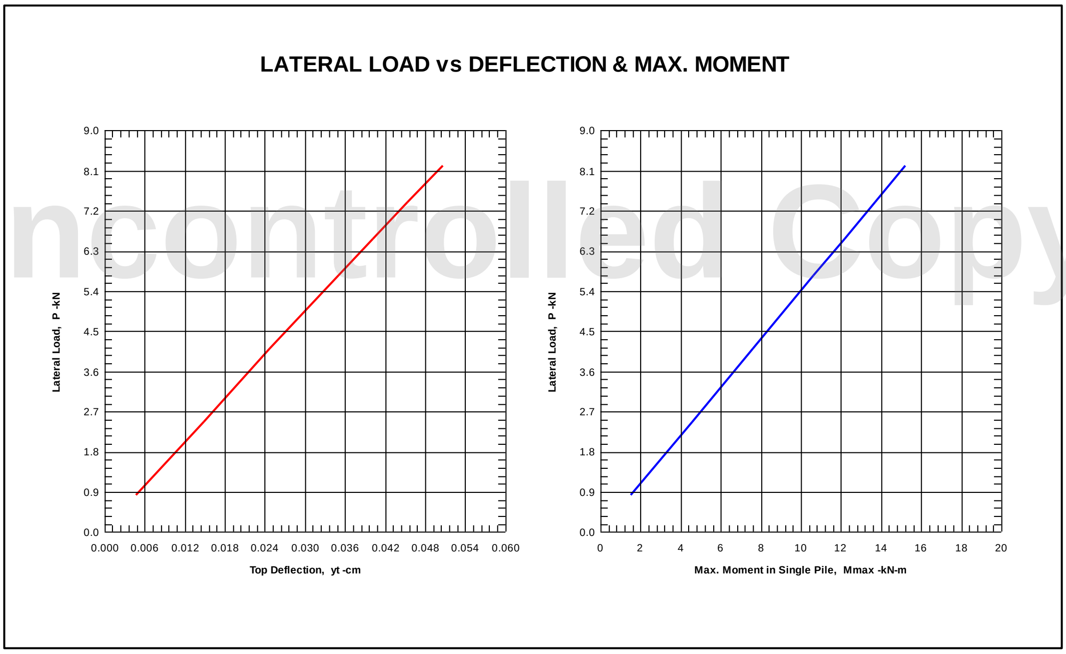


Figure 3-8 Lateral Bearing Capacity of Pile CSP 600 T100 mm for Trestle based on BHL-03

3.3.1. Settlement of Pile

The maximum settlement estimation of pile CSP 600 T100 mm is 0.337 cm. The limitation of pile maximum settlement is 1” or 2.54 cm [8460:2017 SNI GEOTEKNIK chapter 189 and TPKB, chapter 18], so settlement of pile still below the permitted limit (0.337 cm < 2.54 cm, OK!).

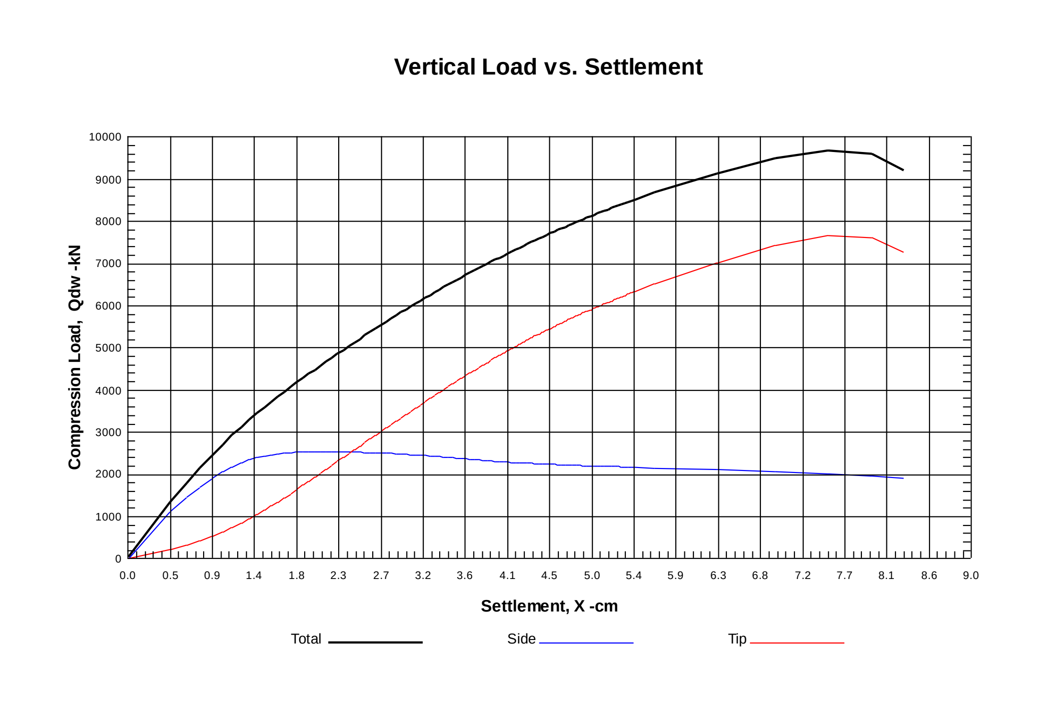


Figure 3-9 Vertical Load vs Total Settlement of Pile CSP 600 T100 mm for Trestle based on BHL-03

3.4. PILE LOAD SEISMIC CONDITIONS BHL-03

Joint reaction result from structure model of Trestle using driven pile CSP 600 T100 mm, can be seen on the table below.

Table 3-4 Summary of Pile Load for Trestle Section 1

Joint Reactions							
CSP 0.60 m Thk 0.10 m							
Load Case	**Output Case**	**F1**	**F2**	**F3**	**M1**	**M2**	**M3**
Text	**Text**	**kN**	**kN**	**kN**	**kN-m**	**kN-m**	**kN-m**
Case Operational	Min	-5.42	-8.22	442.97	-4.68	-19.05	-0.11
	Max	7.77	1.02	989.42	39.37	30.51	0.03
Case Seismic	Min	-3.37	-24.66	114.39	-147.41	-17.40	-2.30
	Max	4.92	24.64	754.76	146.87	21.44	2.31

Summary of the geotechnical analysis is as follows:

- Axial Compression, Pc = 754.76 kN
- Axial Tensile, Pt = 0 kN
- Lateral, H = 24.66 kN

Pile bearing capacity analysis using load from structural analysis result. The result of pile bearing capacity analysis will explained below.

Detail of pile and bor log reference is as follows:

- Pile Type = CSP 600 T100 mm
- Embedded Pile Length = 12 m
- Seabed Elevation = -5 m
- Cut Off Elevation = +3.5 m
- Total Pile Length = 12 + 5 + 3.5 m
  = 21 m
- Reference Bor Log = BHL-03

3.4.1. Check Pile Bearing Capacity

The value of axial compression and axial tension of pile based on borlog BHL-03 (Seismic Condition) is as follows:

DRIVEN CONCRETE SPUN PILE FOUNDATION CARRYING CAPACITY
BASED ON N (SPT) VALUE

PROJECT	: Project di Teluk Waru
LOCATION	: Balikpapan, Kalimantan Timur
BORING NO.	: BHL-03

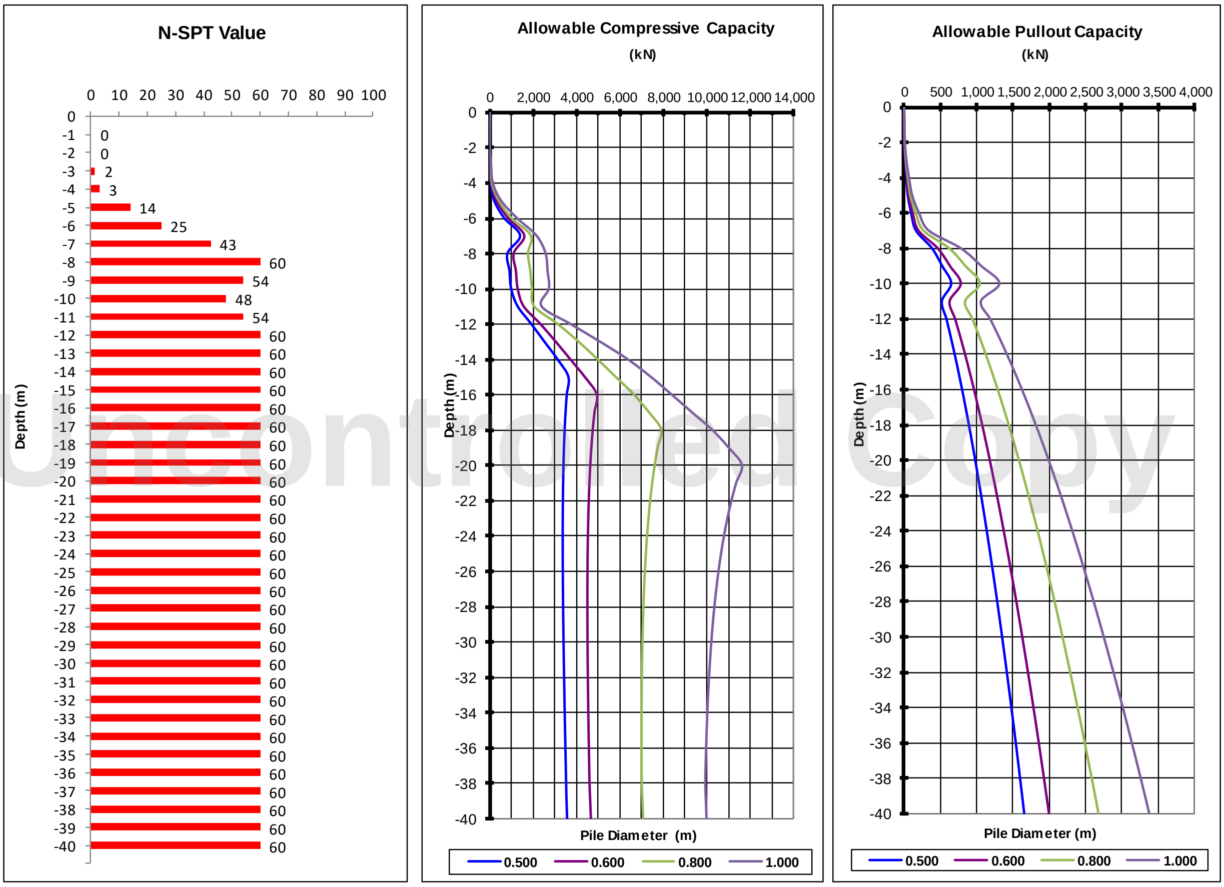


Figure 3-10 Pile Bearing Capacity for Trestle based on BHL-03

Axial Compression Capacity (CSP 600 T100 mm)				
P max	= 754.76	kN		
Pall,c	= 2321.95	kN (based on BHL-03) (SF = 1.5)		
P	= 754.76	<	2321.95	OK!
Axial Tensile Capacity (CSP 600 T100 mm)				
P max	= 0	kN		
Pall,t	= 699.85		kN (based on BHL-03) (SF = 2)	
P	= 0	<	699.85	OK!

3.4.2. Check Lateral Pile Bearing Capacity

Seismic Condition

Pile Type CSP 600 T100 mm

Lateral bearing capacity for vertical pile CSP 600 T100 mm is as follows:

Lateral = 24.66 kN

Lateral load bearing capacity analysis using AllPile computer program (CivilTech Software, U.S). Based on the calculation result, the value of maximum lateral deflection estimation of pile CSP 600 T100 mm (Seismic Condition), is 0.156 cm. The limitation of pile maximum deflection is 1" or 2.54 cm [8460:2017 SNI GEOTEKNIK chapter 190 and TPKB, chapter 19], so deflection of pile still below the permitted limit (0.156 cm < 2.54 cm, OK!).

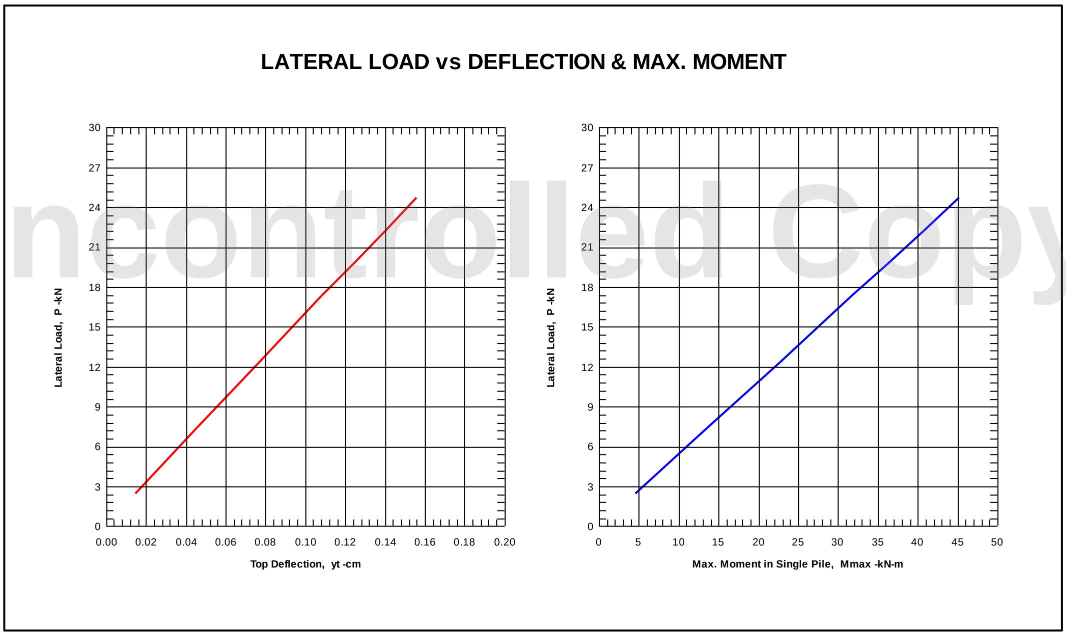


Figure 3-11 Lateral Bearing Capacity of Pile CSP 600 T100 mm for Trestle based on BHL-03

3.4.3. Settlement of Pile

The maximum settlement estimation of pile CSP 600 T100 mm is 0.257 cm. The limitation of pile maximum settlement is 1" or 2.54 cm [8460:2017 SNI GEOTEKNIK chapter 189 and TPKB, chapter 18], so settlement of pile still below the permitted limit (0.257 cm < 2.54 cm, OK!).

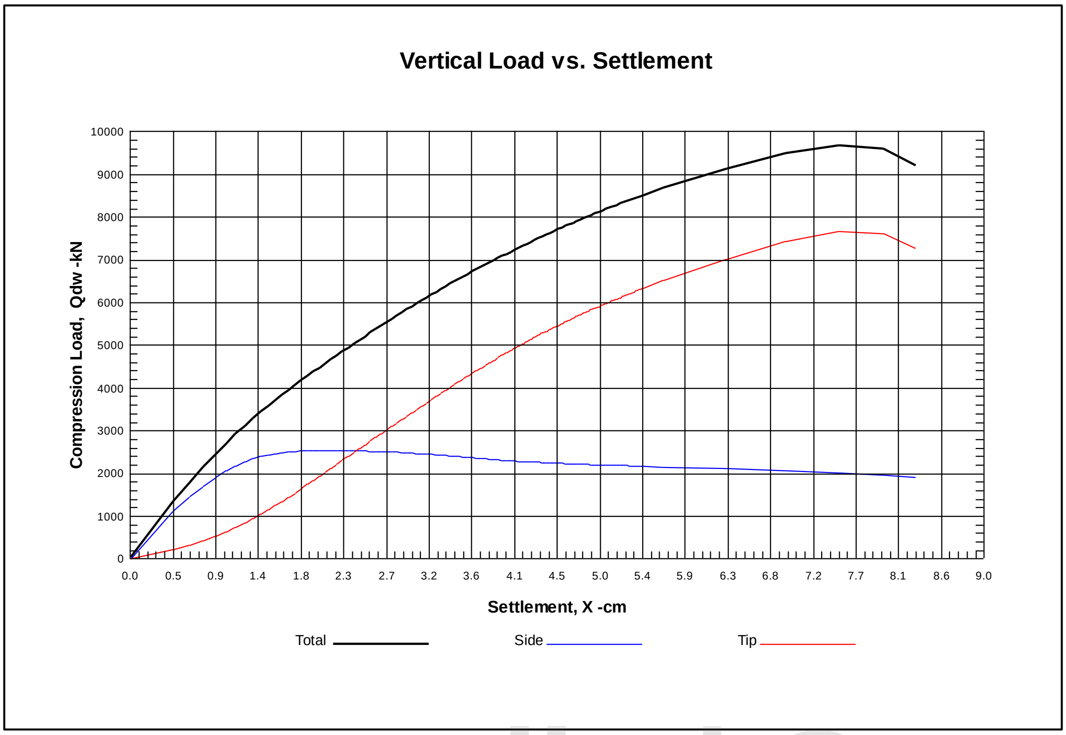


Figure 3-12 Vertical Load vs Total Settlement of Pile CSP 600 T100 mm for Trestle based on BHL-03

4. FOUNDATION DESIGN FOR TRESTLE SECTION 2

4.1. PILE LOAD SERVICE CONDITIONS BHL-03

Joint reaction result from structure model of Trestle using driven pile CSP 600 T100 mm, can be seen on the table below.

Table 4-1 Summary of Pile Load for Trestle Section 2

Joint Reactions							
CSP 0.60 m Thk 0.10 m							
Load Case	**Output Case**	**F1**	**F2**	**F3**	**M1**	**M2**	**M3**
Text	**Text**	**kN**	**kN**	**kN**	**kN-m**	**kN-m**	**kN-m**
Case Operational	Min	-13.30	-11.67	506.24	-2.88	-82.02	-0.17
	Max	1.85	0.45	1069.65	71.21	9.45	3.63
Case Seismic	Min	-36.37	-15.26	170.36	-107.53	-236.12	-6.39
	Max	35.88	15.38	715.79	106.15	233.14	6.27

Summary of the geotechnical analysis is as follows:

- Axial Compression, Pc = 1069.65 kN
- Axial Tensile, Pt = 0 kN
- Lateral, H = 13.30 kN

Pile bearing capacity analysis using load from structural analysis result. The result of pile bearing capacity analysis will explained below.

Detail of pile and bor log reference is as follows:

- Pile Type = CSP 600 T100 mm
- Embedded Pile Length = 12 m
- Seabed Elevation = -5 m
- Cut Off Elevation = +3.5 m
- Total Pile Length = 12 + 5 + 3.5 m
  = 21 m
- Reference Bor Log = BHL-03

4.1.1. Check Pile Bearing Capacity

The value of axial compression and axial tension of pile based on borlog BHL-03 (Service Condition) is as follows:

DRIVEN CONCRETE SPUN PILE FOUNDATION CARRYING CAPACITY
BASED ON N (SPT) VALUE

PROJECT	: Project di Teluk Waru
LOCATION	: Balikpapan, Kalimantan Timur
BORING NO.	: BHL-03

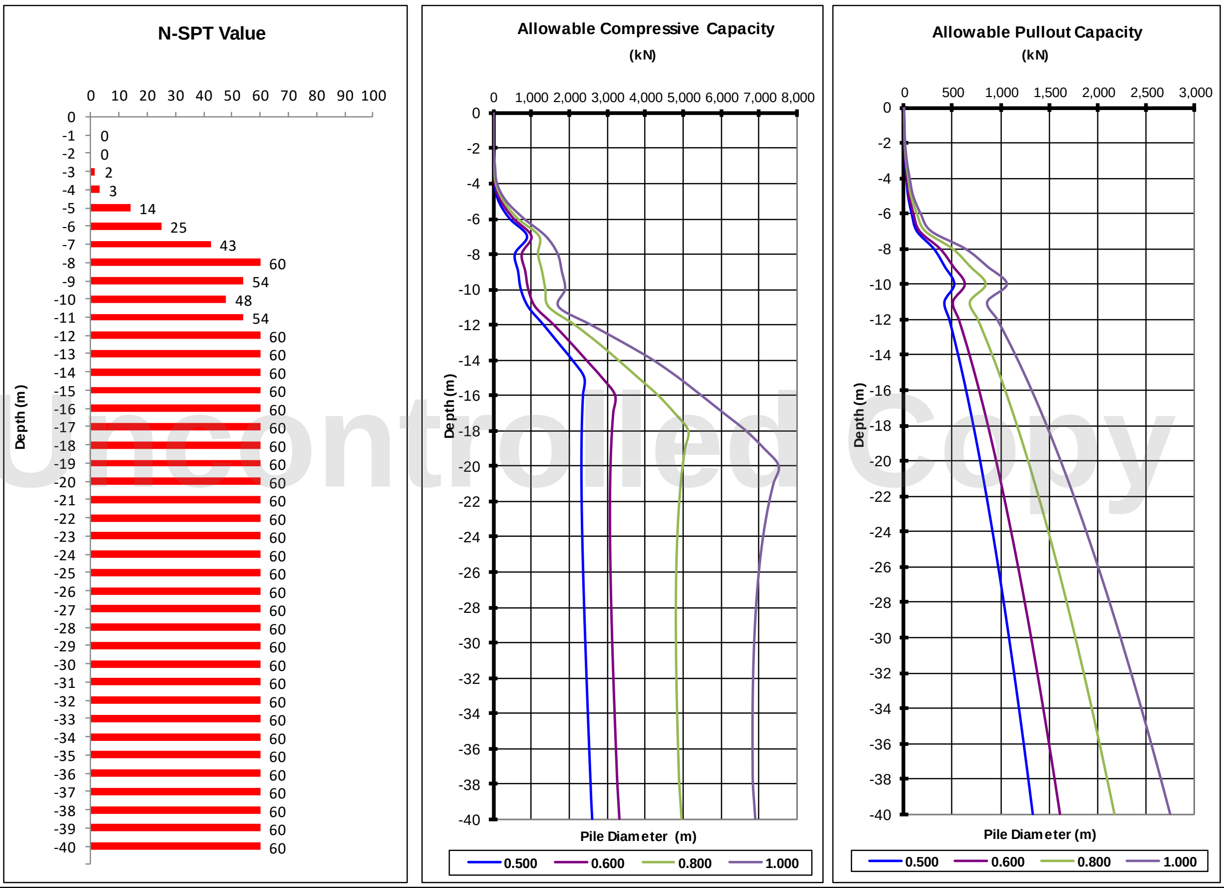


Figure 4-1 Pile Bearing Capacity for Trestle based on BHL-03

Axial Compression Capacity (CSP 600 T100 mm)

P max	= 1069.65	kN		
Pall,c	= 1585.59	kN (based on BHL-03) (SF = 2.5)		
P	= 1069.65	<	1585.59	OK!

Axial Tensile Capacity (CSP 600 T100 mm)

P max	= 0	kN		
Pall,t	= 565.16		kN (based on BHL-03) (SF = 2.5)	
P	= 0	<	565.16	OK!

4.1.2. Check Lateral Pile Bearing Capacity

Service Condition

Pile Type CSP 600 T100 mm

Lateral bearing capacity for vertical pile CSP 600 T100 mm is as follows:

Lateral = 13.30 kN

Lateral load bearing capacity analysis using AllPile computer program (CivilTech Software, U.S). Based on the calculation result, the value of maximum lateral deflection estimation of pile CSP 600 T100 mm (Service Condition), is 0.083 cm. The limitation of pile maximum deflection is 1” or 2.54 cm [8460:2017 SNI GEOTEKNIK chapter 190 and TPKB, chapter 19], so deflection of pile still below the permitted limit (0.083 cm < 2.54 cm, OK!).

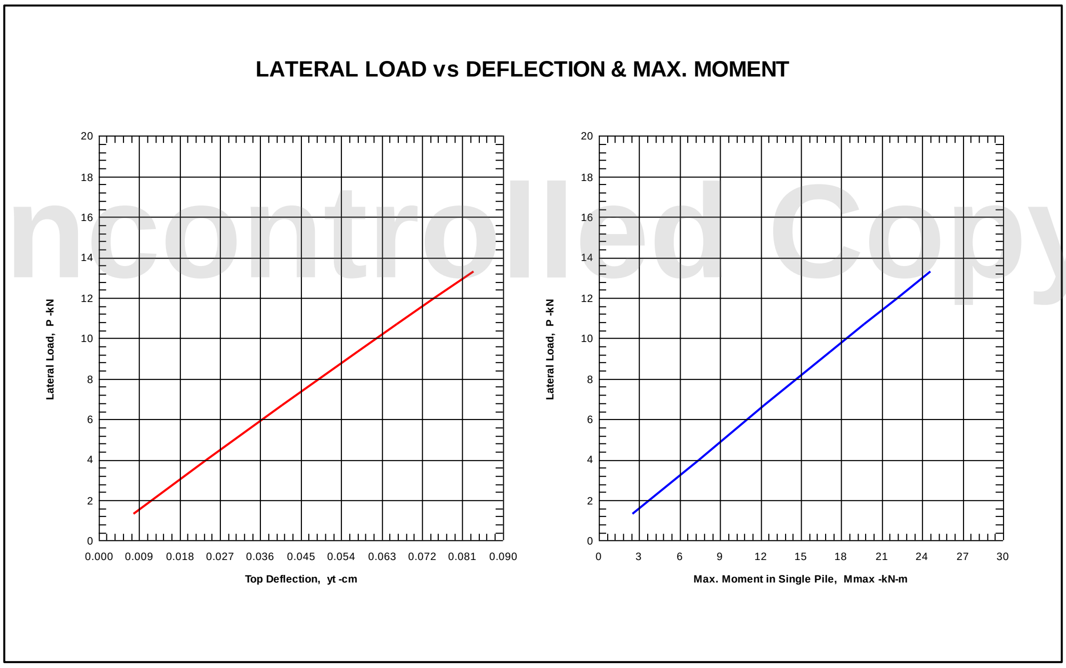


Figure 4-2 Lateral Bearing Capacity of Pile CSP 600 T100 mm for Trestle based on BHL-03

4.1.3. Settlement of Pile

The maximum settlement estimation of pile CSP 600 T100 mm is 0.364 cm. The limitation of pile maximum settlement is 1” or 2.54 cm [8460:2017 SNI GEOTEKNIK chapter 189 and TPKB, chapter 18], so settlement of pile still below the permitted limit (0.364 cm < 2.54 cm, OK!).

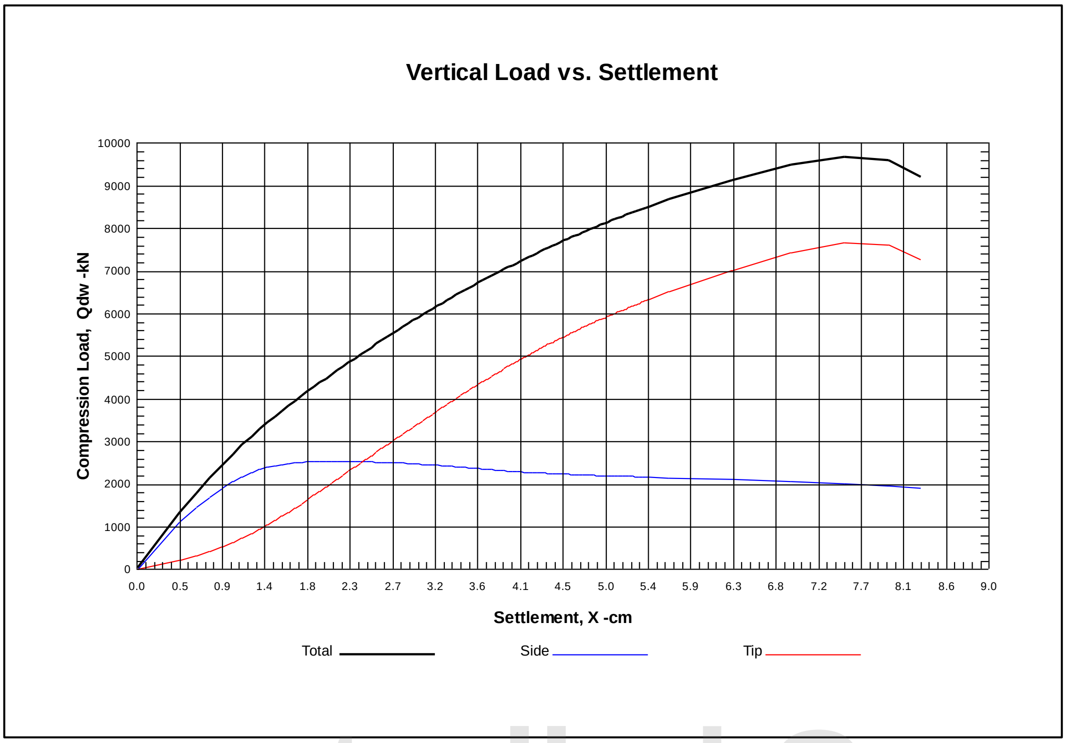


Figure 4-3 Vertical Load vs Total Settlement of Pile CSP 600 T100 mm for Trestle based on BHL-03

4.2. PILE LOAD SEISMIC CONDITIONS BHL-03

Joint reaction result from structure model of Trestle using driven pile CSP 600 T100 mm, can be seen on the table below.

Table 4-2 Summary of Pile Load for Trestle Section 2

Joint Reactions							
CSP 0.60 m Thk 0.10 m							
Load Case	**Output Case**	**F1**	**F2**	**F3**	**M1**	**M2**	**M3**
Text	**Text**	**kN**	**kN**	**kN**	**kN-m**	**kN-m**	**kN-m**
Case Operational	Min	-13.30	-11.67	506.24	-2.88	-82.02	-0.17
	Max	1.85	0.45	1069.65	71.21	9.45	3.63
Case Seismic	Min	-36.37	-15.26	170.36	-107.53	-236.12	-6.39
	Max	35.88	15.38	715.79	106.15	233.14	6.27

Summary of the geotechnical analysis is as follows:

- Axial Compression, Pc = 715.79 kN
- Axial Tensile, Pt = 0 kN
- Lateral, H = 36.37 kN

Pile bearing capacity analysis using load from structural analysis result. The result of pile bearing capacity analysis will explained below.

Detail of pile and bor log reference is as follows:

- Pile Type = CSP 600 T100 mm
- Embedded Pile Length = 12 m
- Seabed Elevation = -5 m
- Cut Off Elevation = +3.5 m
- Total Pile Length = 12 + 5 + 3.5 m
  = 21 m
- Reference Bor Log = BHL-03

4.2.1. Check Pile Bearing Capacity

The value of axial compression and axial tension of pile based on borlog BHL-03 (Seismic Condition) is as follows:

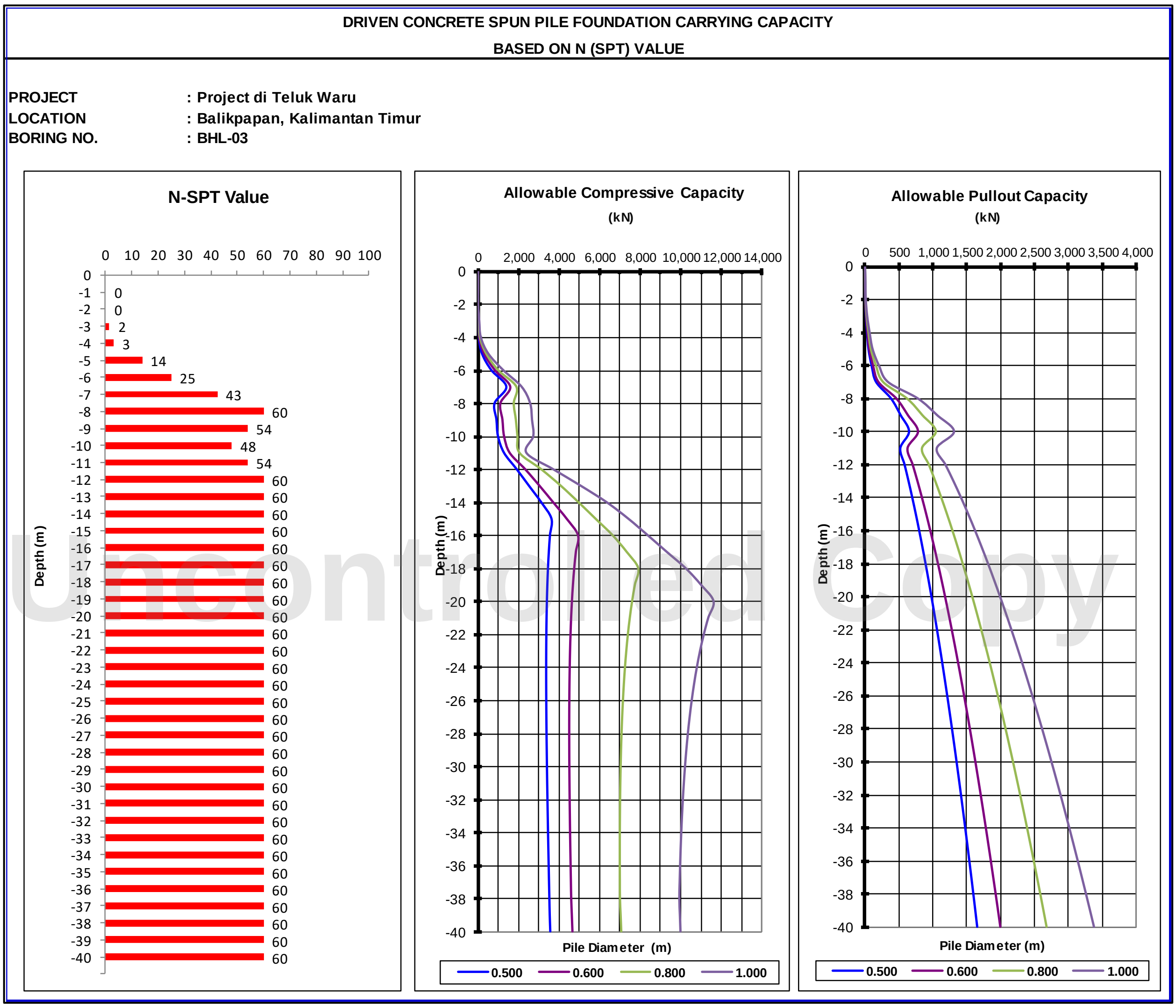


Figure 4-4 Pile Bearing Capacity for Trestle based on BHL-03

Axial Compression Capacity (CSP 600 T100 mm)

P max	= 715.79	kN		
Pall,c	= 2321.95	kN (based on BHL-03) (SF = 1.5)		
P	= 715.79	<	2321.95	OK!

Axial Tensile Capacity (CSP 600 T100 mm)

P max	= 0	kN		
Pall,t	= 699.85		kN (based on BHL-03) (SF = 2)	
P	= 0	<	699.85	OK!

4.2.2. Check Lateral Pile Bearing Capacity

Seismic Condition

Pile Type CSP 600 T100 mm

Lateral bearing capacity for vertical pile CSP 600 T100 mm is as follows:

Lateral = 36.37 kN

Lateral load bearing capacity analysis using AllPile computer program (CivilTech Software, U.S). Based on the calculation result, the value of maximum lateral deflection estimation of pile CSP 600 T100 mm (Seismic Condition), is 0.234 cm. The limitation of pile maximum deflection is 1" or 2.54 cm [8460:2017 SNI GEOTEKNIK chapter 190 and TPKB, chapter 19], so deflection of pile still below the permitted limit (0.234 cm < 2.54 cm, OK!).

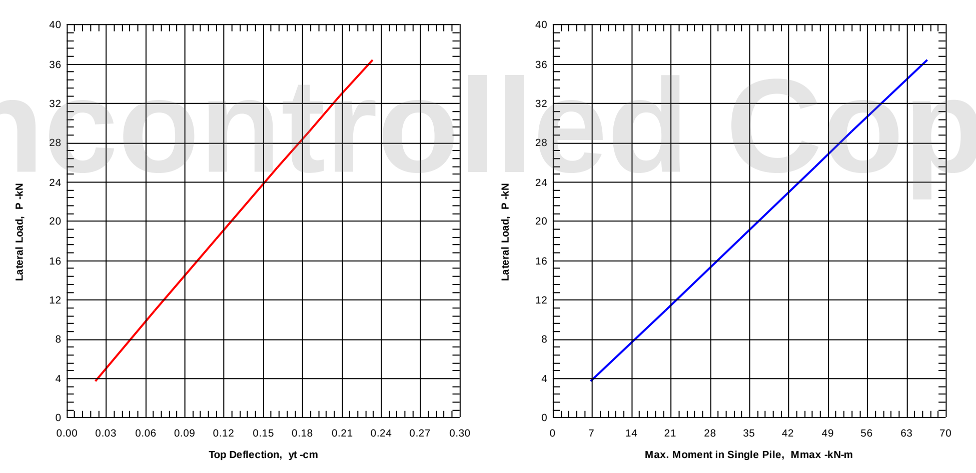


Figure 4-5 Lateral Bearing Capacity of Pile CSP 600 T100 mm for Trestle based on BHL-03

4.2.3. Settlement of Pile

The maximum settlement estimation of pile CSP 600 T100 mm is 0.243 cm. The limitation of pile maximum settlement is 1" or 2.54 cm [8460:2017 SNI GEOTEKNIK chapter 189 and TPKB, chapter 18], so settlement of pile still below the permitted limit (0.243 cm < 2.54 cm, OK!).

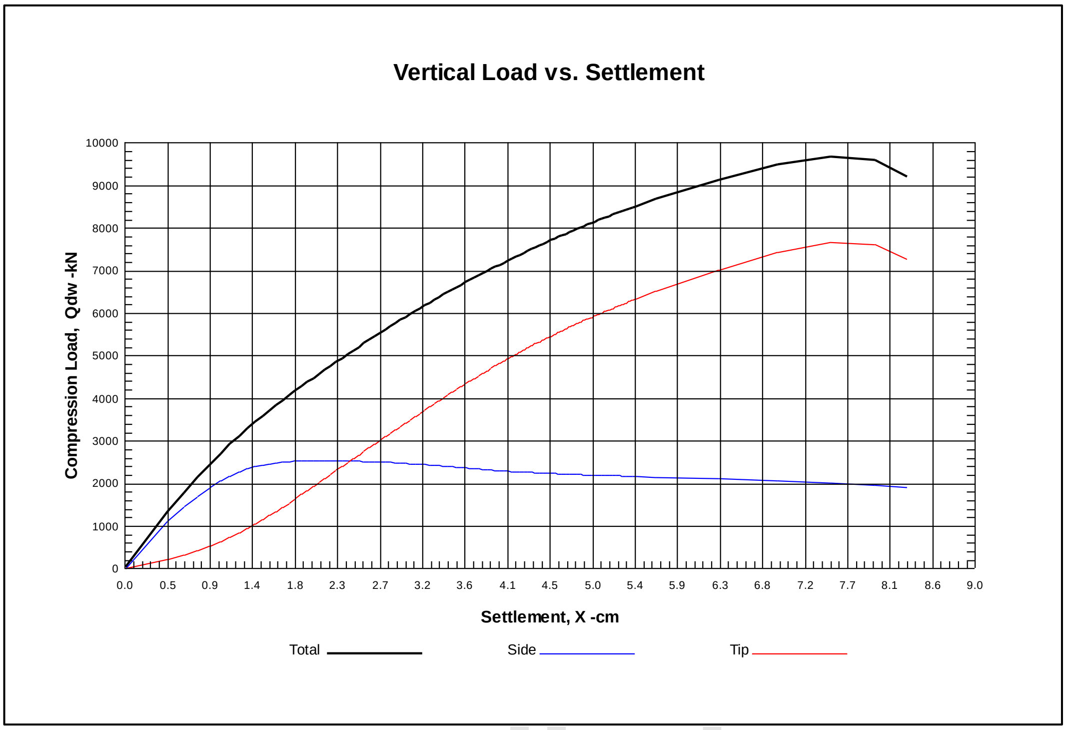


Figure 4-6 Vertical Load vs Total Settlement of Pile CSP 600 T100 mm for Trestle based on BHL-03

4.3. PILE LOAD SERVICE CONDITIONS BHL-04 CSP 600 T100 mm

Joint reaction result from structure model of Trestle using driven pile CSP 600 T100 mm, can be seen on the table below.

Table 4-3 Summary of Pile Load for Trestle Section 2

Joint Reactions							
CSP 0.60 m Thk 0.10 m							
Load Case	**Output Case**	**F1**	**F2**	**F3**	**M1**	**M2**	**M3**
Text	**Text**	**kN**	**kN**	**kN**	**kN-m**	**kN-m**	**kN-m**
Case Operational	Min	-13.30	-11.67	506.24	-2.88	-82.02	-0.17
	Max	1.85	0.45	1069.65	71.21	9.45	3.63
Case Seismic	Min	-36.37	-15.26	170.36	-107.53	-236.12	-6.39
	Max	35.88	15.38	715.79	106.15	233.14	6.27

Summary of the geotechnical analysis is as follows:

- Axial Compression, Pc = 1069.65 kN
- Axial Tensile, Pt = 0 kN
- Lateral, H = 13.30 kN

Pile bearing capacity analysis using load from structural analysis result. The result of pile bearing capacity analysis will explained below.

Detail of pile and bor log reference is as follows:

- Pile Type = CSP 600 T100 mm

- Embedded Pile Length = 12 m
- Seabed Elevation = -5 m
- Cut Off Elevation = +3.5 m
- Total Pile Length = 12 + 5 + 3.5 m
  = 21 m
- Reference Bor Log = BHL-04

4.3.1. Check Pile Bearing Capacity

The value of axial compression and axial tension of pile based on borlog BHL-04 (Service Condition) is as follows:

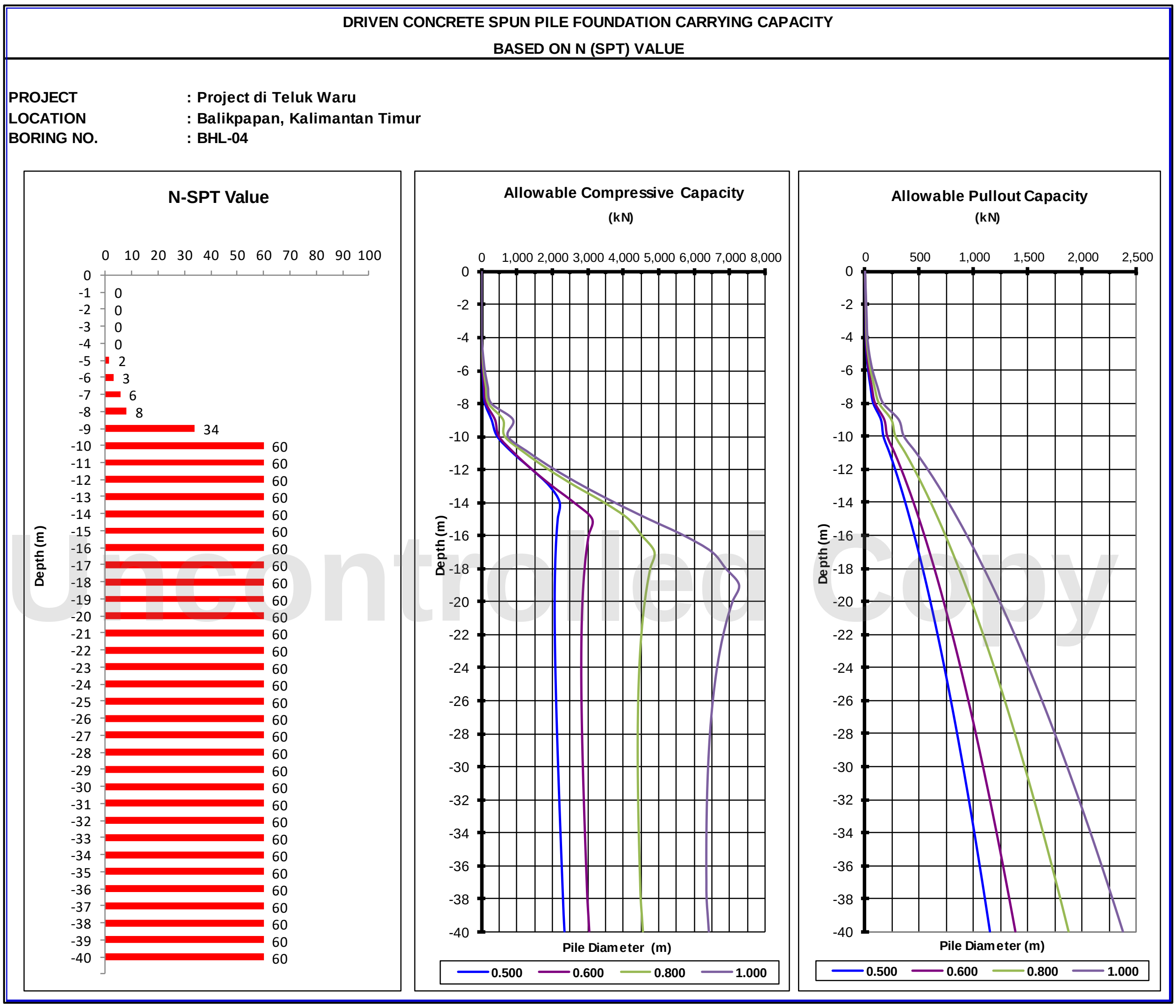


Figure 4-7 Pile Bearing Capacity for Trestle based on BHL-04

Axial Compression Capacity (CSP 600 T100 mm)

P max = 1069.65 kN

Pall,c = 1412.10 kN (based on BHL-04) (SF = 2.5)

P = 1069.65 < 1412.1 OK!

Axial Tensile Capacity (CSP 600 T100 mm)

P max = 0 kN

Pall,t = 334.61 kN (based on BHL-04) (SF = 2.5)

P = 0 < 334.61 OK!

4.3.2. Check Lateral Pile Bearing Capacity

Service Condition

Pile Type CSP 600 T100 mm

Lateral bearing capacity for vertical pile CSP 600 T100 mm is as follows:

Lateral = 13.30 kN

Lateral load bearing capacity analysis using AllPile computer program (CivilTech Software, U.S). Based on the calculation result, the value of maximum lateral deflection estimation of pile CSP 600 T100 mm (Service Condition), is 0.028 cm. The limitation of pile maximum deflection is 1” or 2.54 cm [8460:2017 SNI GEOTEKNIK chapter 190 and TPKB, chapter 19], so deflection of pile still below the permitted limit (0.028 cm < 2.54 cm, OK!).

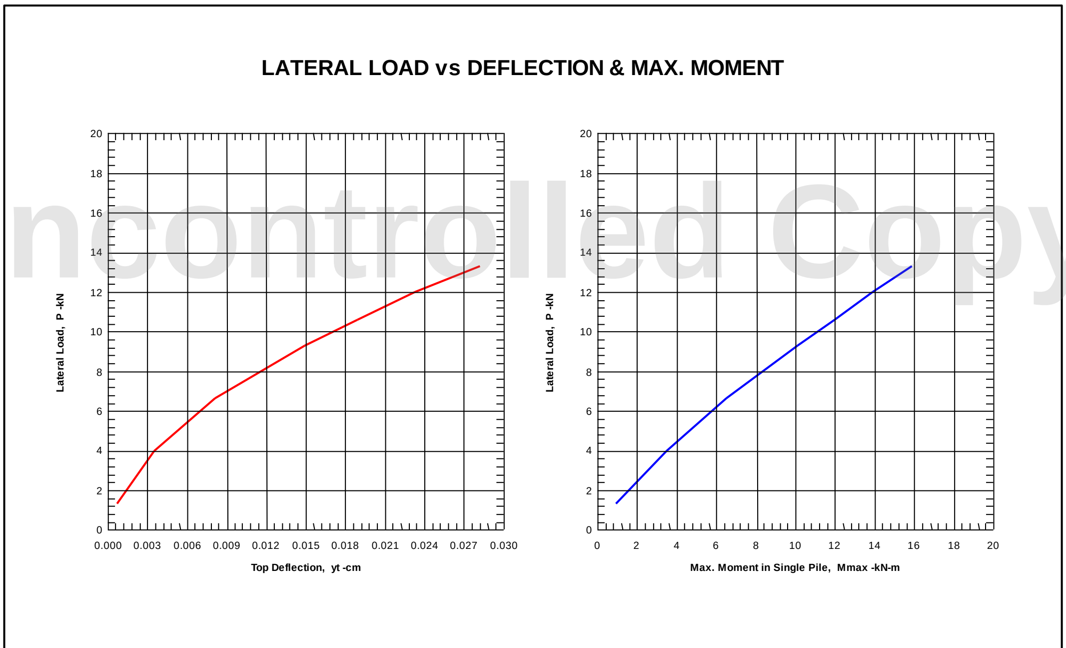


Figure 4-8 Lateral Bearing Capacity of Pile CSP 600 T100 mm for Trestle based on BHL-04

4.3.3. Settlement of Pile

The maximum settlement estimation of pile CSP 600 T100 mm is 0.376 cm. The limitation of pile maximum settlement is 1” or 2.54 cm [8460:2017 SNI GEOTEKNIK chapter 189 and TPKB, chapter 18], so settlement of pile still below the permitted limit (0.376 cm < 2.54 cm, OK!).

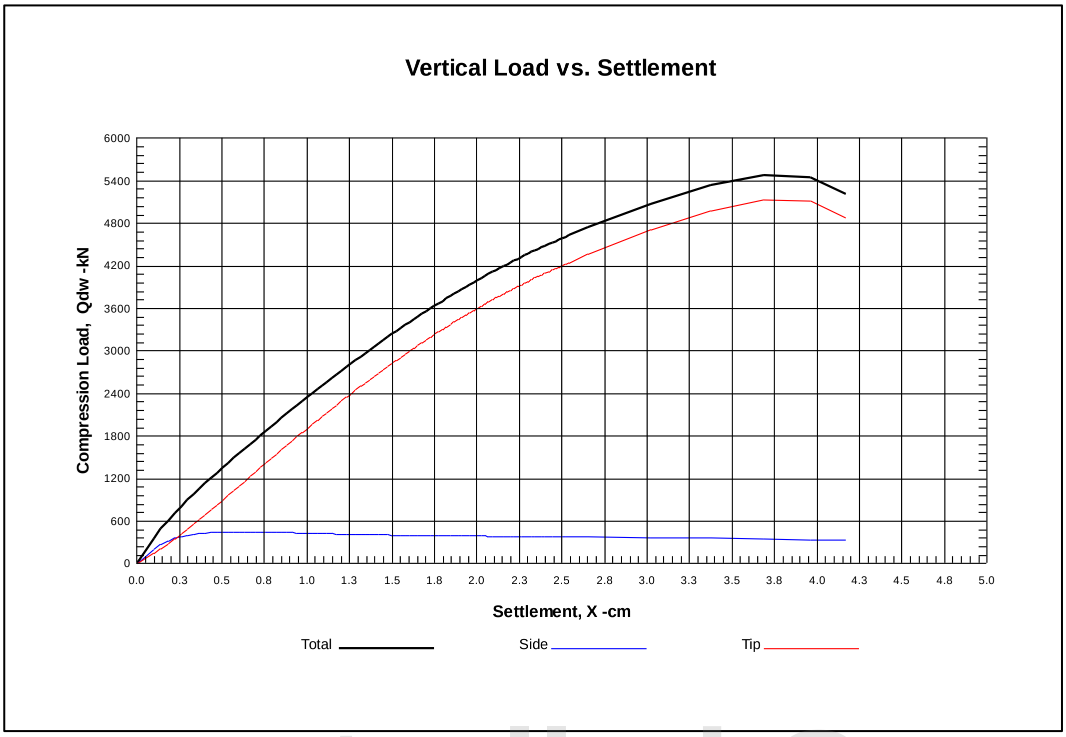


Figure 4-9 Vertical Load vs Total Settlement of Pile CSP 600 T100 mm for Trestle based on BHL-04

4.4. PILE LOAD SEISMIC CONDITIONS BHL-04 CSP 600 T100 mm

Joint reaction result from structure model of Trestle using driven pile CSP 600 T100 mm, can be seen on the table below.

Table 4-4 Summary of Pile Load for Trestle Section 2

Joint Reactions							
CSP 0.60 m Thk 0.10 m							
Load Case	**Output Case**	**F1**	**F2**	**F3**	**M1**	**M2**	**M3**
Text	**Text**	**kN**	**kN**	**kN**	**kN-m**	**kN-m**	**kN-m**
Case Operational	Min	-13.30	-11.67	506.24	-2.88	-82.02	-0.17
	Max	1.85	0.45	1069.65	71.21	9.45	3.63
Case Seismic	Min	-36.37	-15.26	170.36	-107.53	-236.12	-6.39
	Max	35.88	15.38	715.79	106.15	233.14	6.27

Summary of the geotechnical analysis is as follows:

- Axial Compression, Pc = 715.79 kN
- Axial Tensile, Pt = 0 kN
- Lateral, H = 36.37 kN

Pile bearing capacity analysis using load from structural analysis result. The result of pile bearing capacity analysis will explained below.

Detail of pile and bor log reference is as follows:

- Pile Type = CSP 600 T100 mm
- Embedded Pile Length = 12 m
- Seabed Elevation = -5 m
- Cut Off Elevation = +3.5 m
- Total Pile Length = 12 + 5 + 3.5 m

  = 21 m
- Reference Bor Log = BHL-04

4.4.1. Check Pile Bearing Capacity

The value of axial compression and axial tension of pile based on borlog BHL-04 (Seismic Condition) is as follows:

DRIVEN CONCRETE SPUN PILE FOUNDATION CARRYING CAPACITY
BASED ON N (SPT) VALUE

PROJECT	: Project di Teluk Waru
LOCATION	: Balikpapan, Kalimantan Timur
BORING NO.	: BHL-04

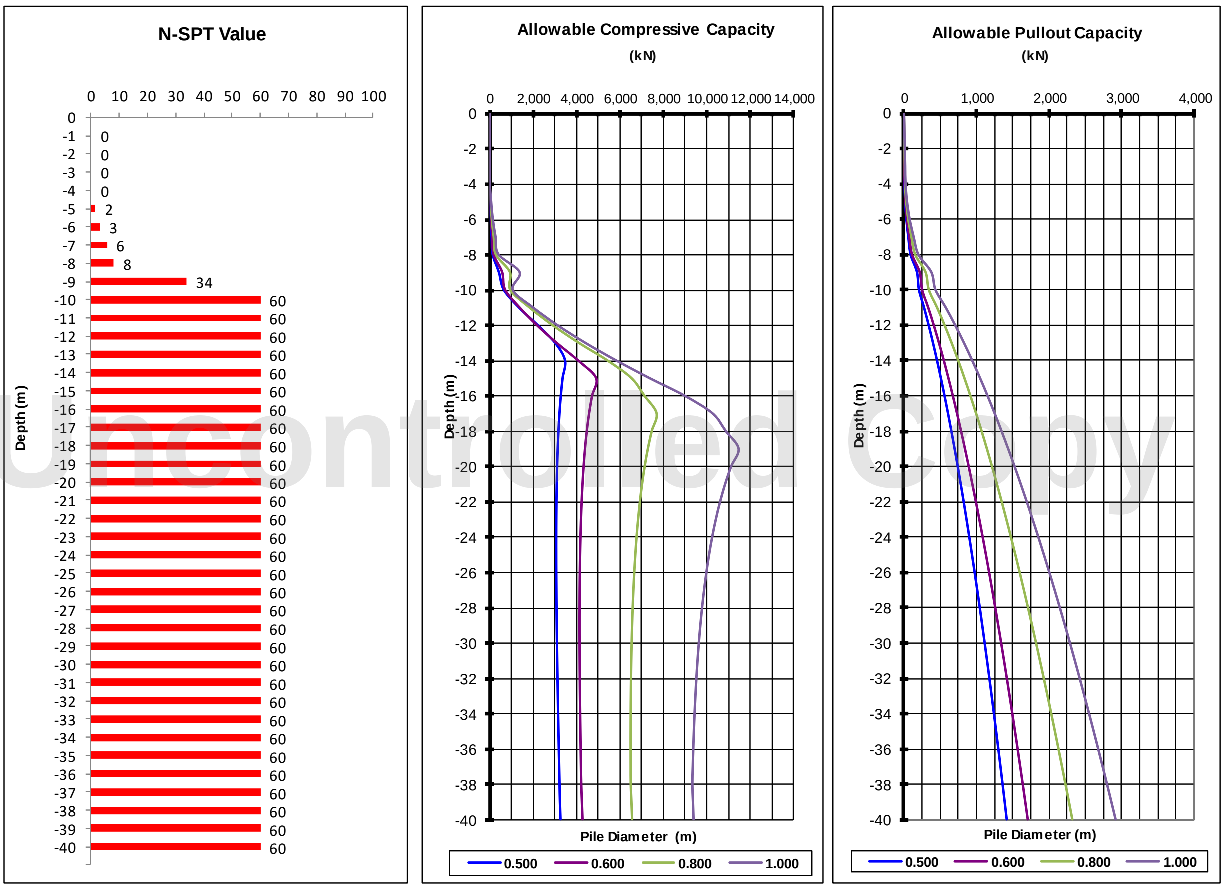


Figure 4-10 Pile Bearing Capacity for Trestle based on BHL-04

Axial Compression Capacity (CSP 600 T100 mm)

P max	= 715.79	kN		
Pall,c	= 2170.03	kN (based on BHL-04) (SF = 1.5)		
P	= 715.79	<	2170.03	OK!

Axial Tensile Capacity (CSP 600 T100 mm)

P max	= 0	kN		
Pall,t	= 411.67		kN (based on BHL-04) (SF = 2)	
P	= 0	<	411.67	OK!

4.4.2. Check Lateral Pile Bearing Capacity

Seismic Condition

Pile Type CSP 600 T100 mm

Lateral bearing capacity for vertical pile CSP 600 T100 mm is as follows:

Lateral = 36.37 kN

Lateral load bearing capacity analysis using AllPile computer program (CivilTech Software, U.S). Based on the calculation result, the value of maximum lateral deflection estimation of pile CSP 600 T100 mm (Seismic Condition), is 0.163 cm. The limitation of pile maximum deflection is 1" or 2.54 cm [8460:2017 SNI GEOTEKNIK chapter 190 and TPKB, chapter 19], so deflection of pile still below the permitted limit (0.163 cm < 2.54 cm, OK!).

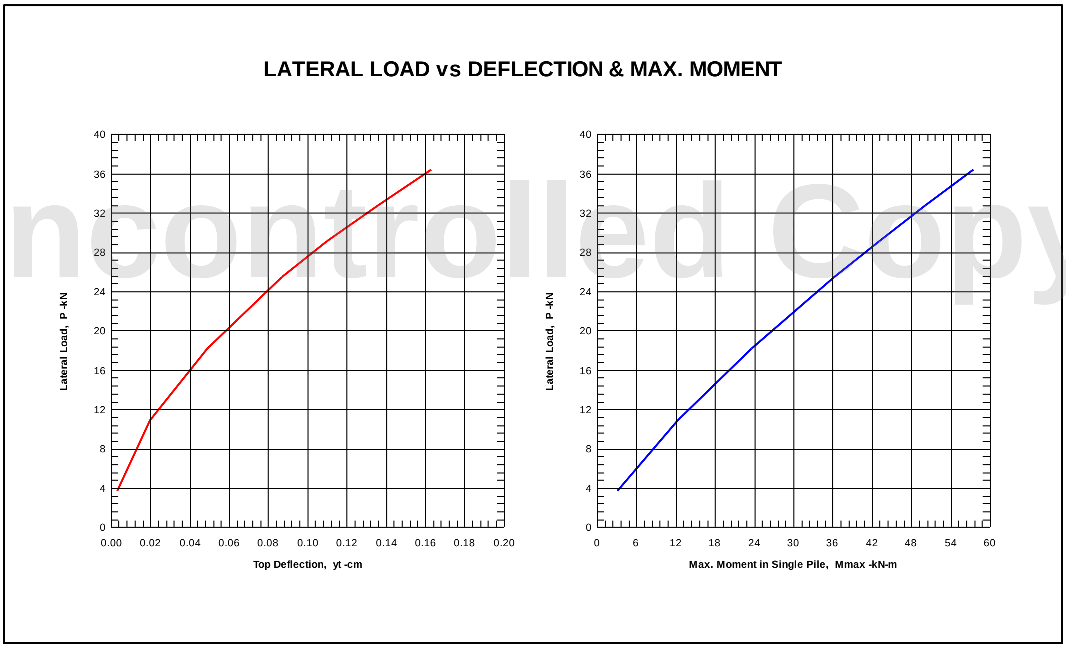


Figure 4-11 Lateral Bearing Capacity of Pile CSP 600 T100 mm for Trestle based on BHL-04

4.4.3. Settlement of Pile

The maximum settlement estimation of pile CSP 600 T100 mm is 0.227 cm. The limitation of pile maximum settlement is 1" or 2.54 cm [8460:2017 SNI GEOTEKNIK chapter 189 and TPKB, chapter 18], so settlement of pile still below the permitted limit (0.227 cm < 2.54 cm, OK!).

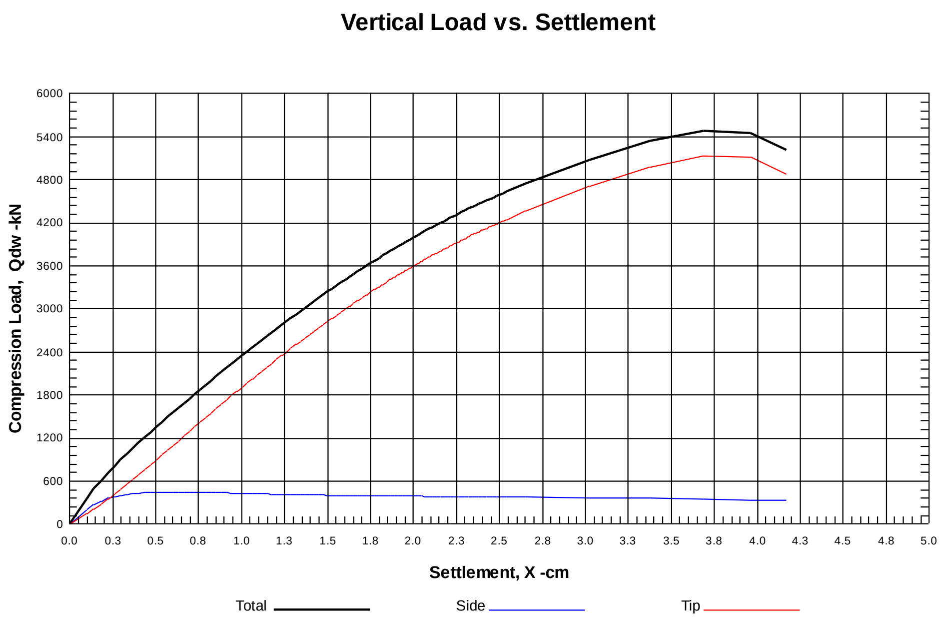


Figure 4-12 Vertical Load vs Total Settlement of Pile CSP 600 T100 mm for Trestle based on BHL-04

4.5. PILE LOAD SERVICE CONDITIONS BHL-04 SPP 711 T12 mm

Joint reaction result from structure model of Trestle using driven pile SPP 711 T12 mm, can be seen on the table below.

Table 4-5 Summary of Pile Load for Trestle Section 2

Joint Reactions							
SPP 0.711 m Thk 0.012 m							
Load Case	**Output Case**	**F1**	**F2**	**F3**	**M1**	**M2**	**M3**
Text	**Text**	**kN**	**kN**	**kN**	**kN-m**	**kN-m**	**kN-m**
Case Operational	Min	-10.71	-13.35	231.99	-3.75	-82.90	-0.20
	Max	1.75	0.36	926.35	127.48	18.85	4.33
Case Seismic	Min	-20.38	-16.01	73.49	-174.82	-198.99	-7.80
	Max	20.13	16.11	672.67	173.91	196.67	7.65

Summary of the geotechnical analysis is as follows:

- Axial Compression, Pc = 926.35 kN
- Axial Tensile, Pt = 0 kN
- Lateral, H = 13.35 kN

Pile bearing capacity analysis using load from structural analysis result. The result of pile bearing capacity analysis will explained below.

Detail of pile and bor log reference is as follows:

- Pile Type = SPP 711 T12 mm
- Embedded Pile Length = 13 m
- Seabed Elevation = -11 m
- Cut Off Elevation = +3.5 m
- Total Pile Length = 13 + 11 + 3.5 m
  = 28 m
- Reference Bor Log = BHL-04

4.5.1. Check Pile Bearing Capacity

The value of axial compression and axial tension of pile based on borlog BHL-04 (Service Condition) is as follows:

DRIVEN STEEL PIPE PILE FOUNDATION CARRYING CAPACITY
BASED ON N (SPT) VALUE

PROJECT : Project di Teluk Waru
LOCATION : Balikpapan, Kalimantan Timur
BORING NO. : BHL-04

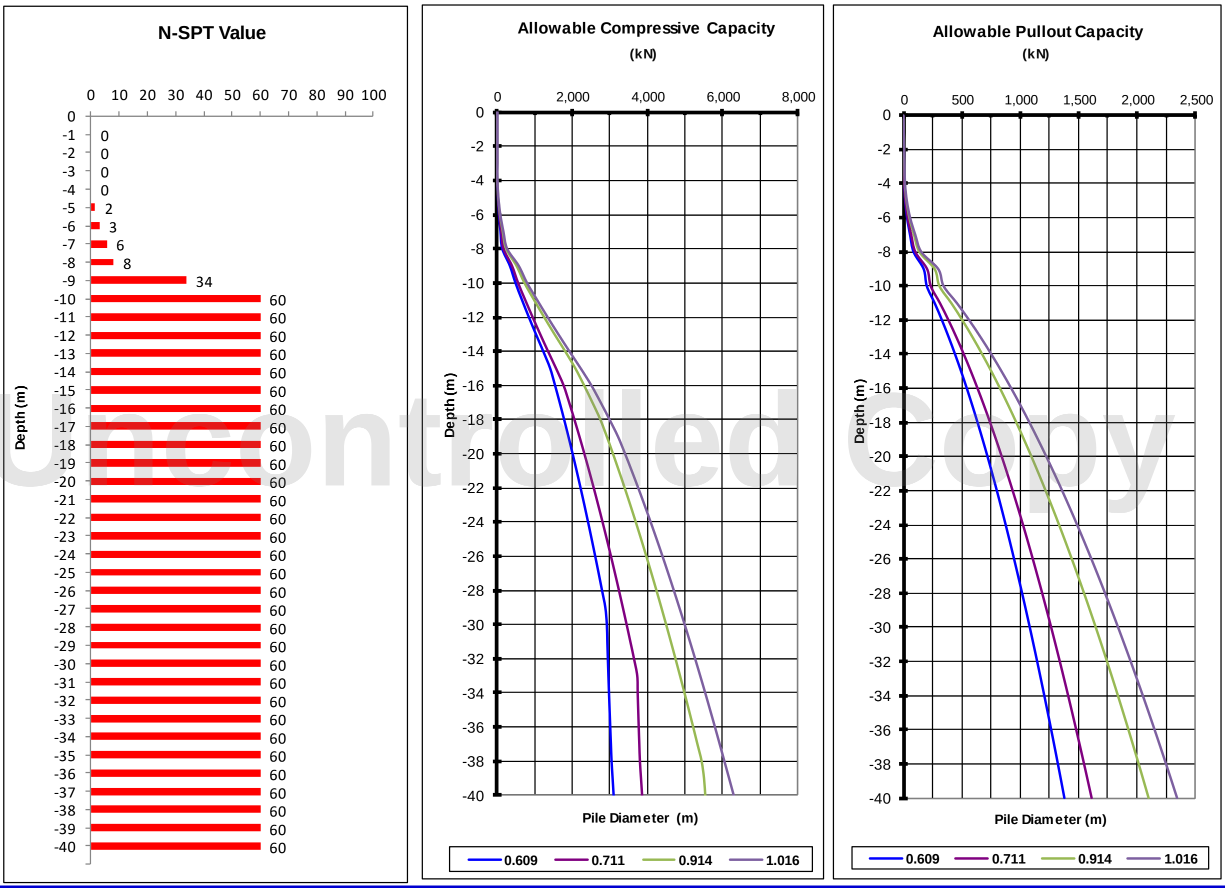


Figure 4-13 Pile Bearing Capacity for Trestle based on BHL-04

Axial Compression Capacity (SPP 711 T12 mm)

P max	= 926.35	kN		
Pall,c	= 1140.93	kN (based on BHL-04) (SF = 2.5)		
P	= 926.35	<	1140.93	OK!

Axial Tensile Capacity (SPP 711 T12 mm)

P max	= 0	kN		
Pall,t	= 454.71		kN (based on BHL-04) (SF = 2.5)	
P	= 0	<	454.71	OK!

4.5.2. Check Lateral Pile Bearing Capacity

Service Condition

Pile Type SPP 711 T12 mm

Lateral bearing capacity for vertical pile SPP 711 T12 mm is as follows:

Lateral = 13.35 kN

Lateral load bearing capacity analysis using AllPile computer program (CivilTech Software, U.S). Based on the calculation result, the value of maximum lateral deflection estimation of pile SPP 711 T12 mm (Service Condition), is 0.014 cm. The limitation of pile maximum deflection is 1" or 2.54 cm [8460:2017 SNI GEOTEKNIK chapter 190 and TPKB, chapter 19], so deflection of pile still below the permitted limit (0.014 cm < 2.54 cm, OK!).

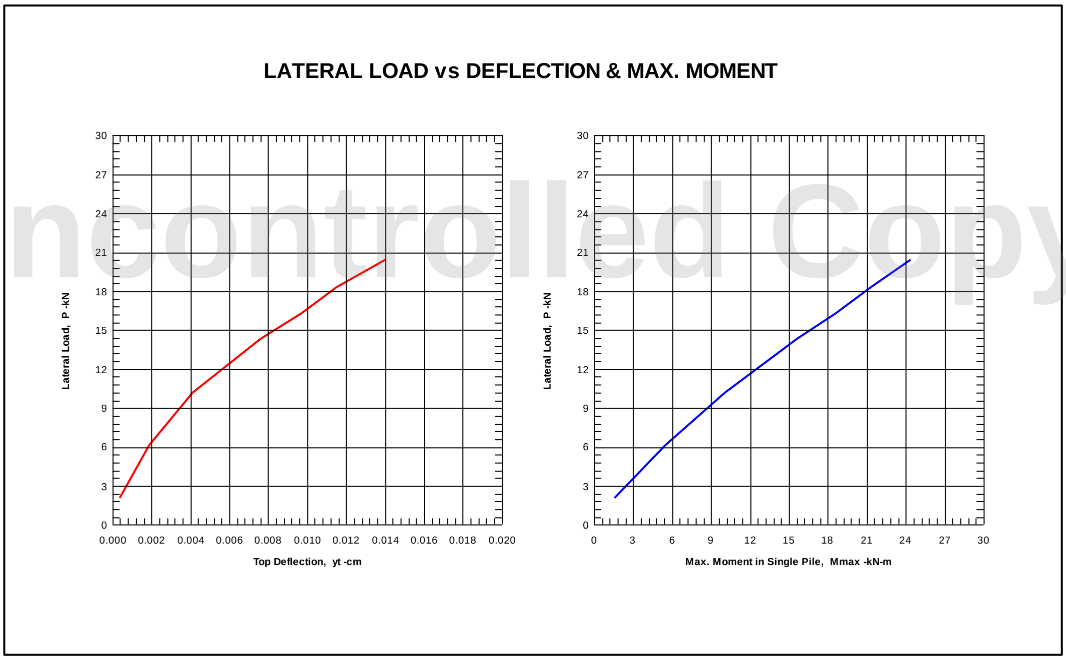


Figure 4-14 Lateral Bearing Capacity of Pile SPP 711 T12 mm for Trestle based on BHL-04

4.5.3. Settlement of Pile

The maximum settlement estimation of pile SPP 711 T12 mm is 0.125 cm. The limitation of pile maximum settlement is 1" or 2.54 cm [8460:2017 SNI GEOTEKNIK chapter 189 and TPKB, chapter 18], so settlement of pile still below the permitted limit (0.125 cm < 2.54 cm, OK!).

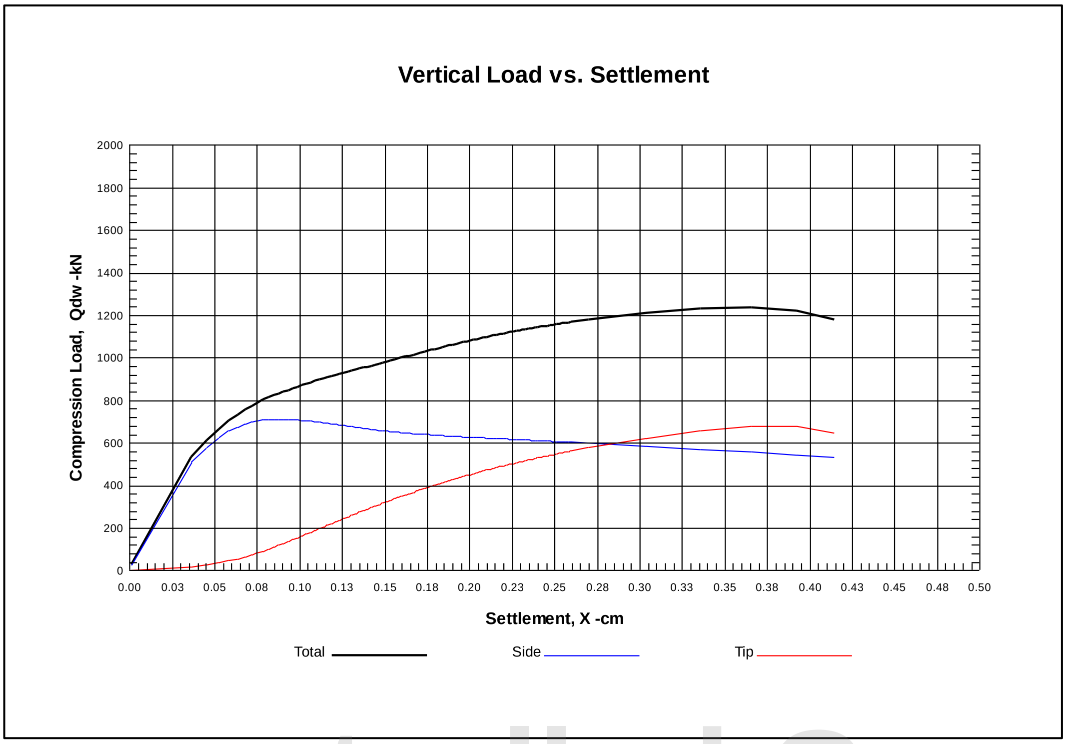


Figure 4-15 Vertical Load vs Total Settlement of Pile SPP 711 T12 mm for Trestle based on BHL-04

4.6. PILE LOAD SEISMIC CONDITIONS BHL-04 SPP 711 T12 mm

Joint reaction result from structure model of Trestle using driven pile SPP 711 T12 mm, can be seen on the table below.

Table 4-6 Summary of Pile Load for Trestle Section 2

Joint Reactions							
SPP 0.711 m Thk 0.012 m							
Load Case	**Output Case**	**F1**	**F2**	**F3**	**M1**	**M2**	**M3**
Text	**Text**	**kN**	**kN**	**kN**	**kN-m**	**kN-m**	**kN-m**
Case Operational	Min	-10.71	-13.35	231.99	-3.75	-82.90	-0.20
	Max	1.75	0.36	926.35	127.48	18.85	4.33
Case Seismic	Min	-20.38	-16.01	73.49	-174.82	-198.99	-7.80
	Max	20.13	16.11	672.67	173.91	196.67	7.65

Summary of the geotechnical analysis is as follows:

- Axial Compression, Pc = 672.67 kN
- Axial Tensile, Pt = 0 kN
- Lateral, H = 20.38 kN

Pile bearing capacity analysis using load from structural analysis result. The result of pile bearing capacity analysis will explained below.

Detail of pile and bor log reference is as follows:

- Pile Type = SPP 711 T12 mm
- Embedded Pile Length = 13 m
- Seabed Elevation = -11 m
- Cut Off Elevation = +3.5 m
- Total Pile Length = 13 + 11 + 3.5 m
  = 28 m
- Reference Bor Log = BHL-04

4.6.1. Check Pile Bearing Capacity

The value of axial compression and axial tension of pile based on borlog BHL-04 (Seismic Condition) is as follows:

DRIVEN STEEL PIPE PILE FOUNDATION CARRYING CAPACITY
BASED ON N (SPT) VALUE

PROJECT : Project di Teluk Waru
LOCATION : Balikpapan, Kalimantan Timur
BORING NO. : BHL-04

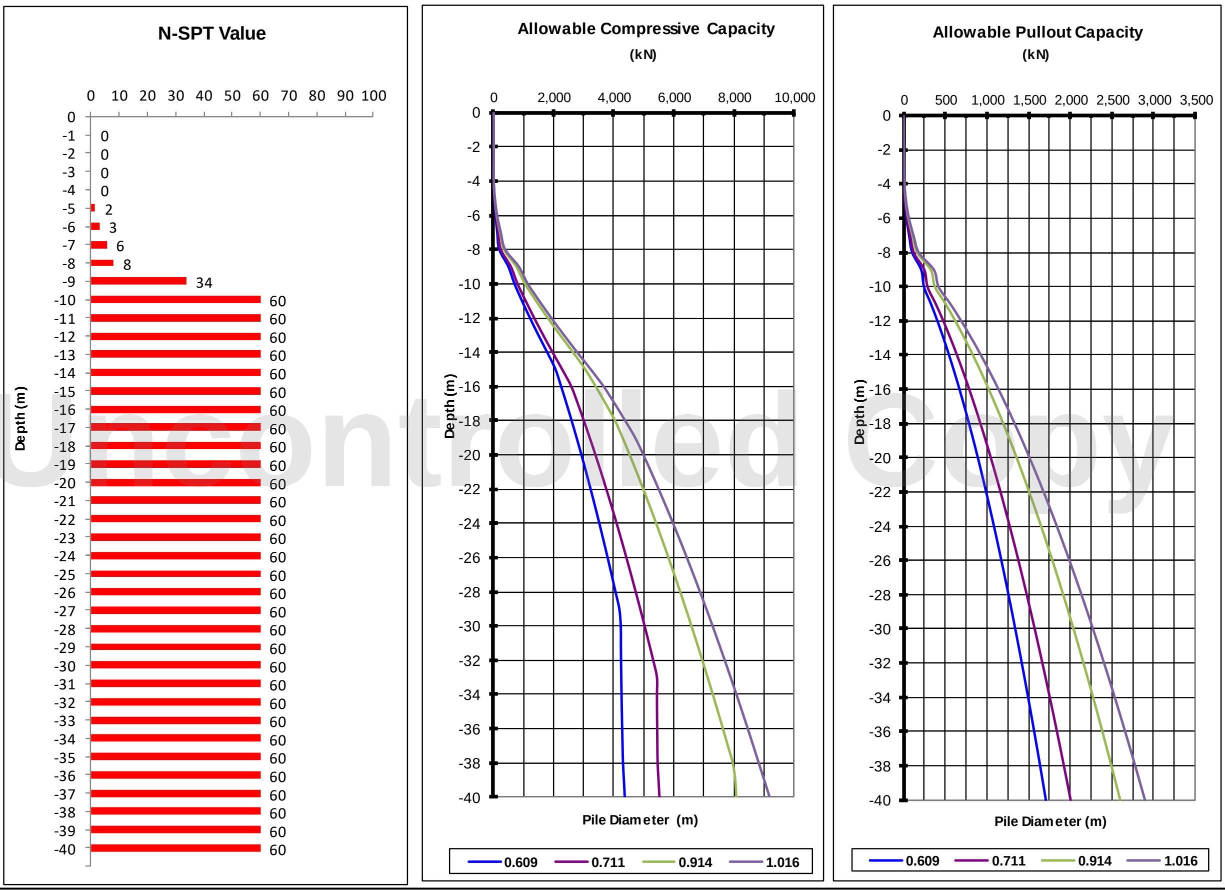


Figure 4-16 Pile Bearing Capacity for Trestle based on BHL-04

Axial Compression Capacity (SPP 711 T12 mm)

P max	= 672.67	kN		
Pall,c	= 1644.85	kN (based on BHL-04) (SF = 1.5)		
P	= 672.67	<	1644.85	OK!

Axial Tensile Capacity (SPP 711 T12 mm)

P max	= 0	kN		
Pall,t	= 562.53		kN (based on BHL-04) (SF = 2)	
P	= 0	<	562.53	OK!

4.6.2. Check Lateral Pile Bearing Capacity

Seismic Condition

Pile Type SPP 711 T12 mm

Lateral bearing capacity for vertical pile SPP 711 T12 mm is as follows:

Lateral = 20.38 kN

Lateral load bearing capacity analysis using AllPile computer program (CivilTech Software, U.S). Based on the calculation result, the value of maximum lateral deflection estimation of pile SPP 711 T12 mm (Seismic Condition), is 0.014 cm. The limitation of pile maximum deflection is 1" or 2.54 cm [8460:2017 SNI GEOTEKNIK chapter 190 and TPKB, chapter 19], so deflection of pile still below the permitted limit (0.014 cm < 2.54 cm, OK!).

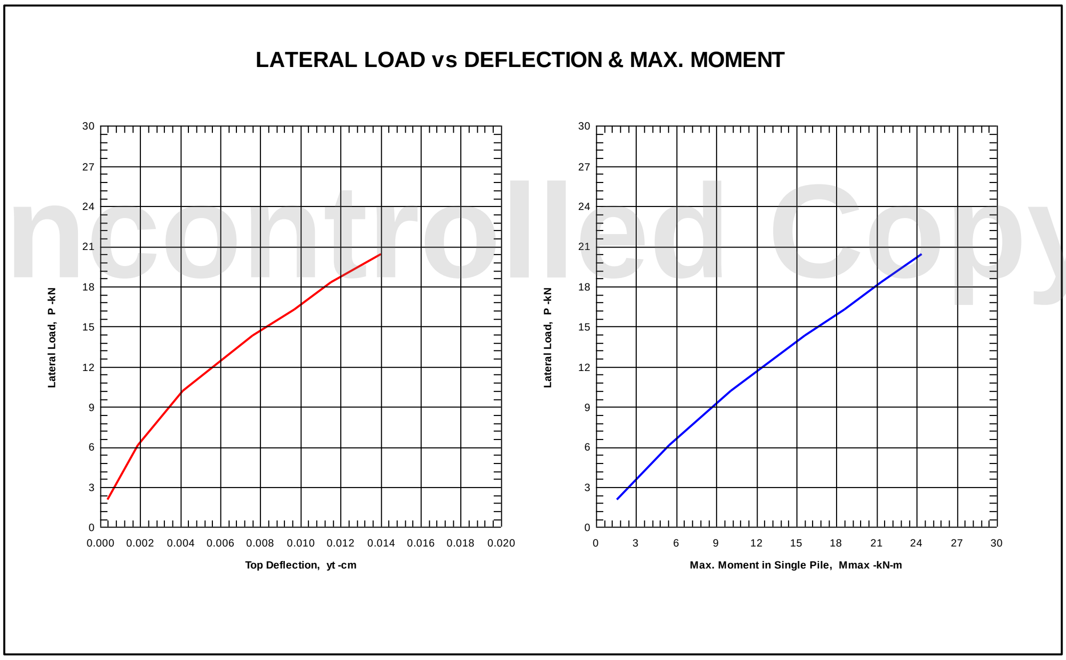


Figure 4-17 Lateral Bearing Capacity of Pile SPP 711 T12 mm for Trestle based on BHL-04

4.6.3. Settlement of Pile

The maximum settlement estimation of pile SPP 711 T12 mm is 0.054 cm. The limitation of pile maximum settlement is 1" or 2.54 cm [8460:2017 SNI GEOTEKNIK chapter 189 and TPKB, chapter 18], so settlement of pile still below the permitted limit (0.054 cm < 2.54 cm, OK!).

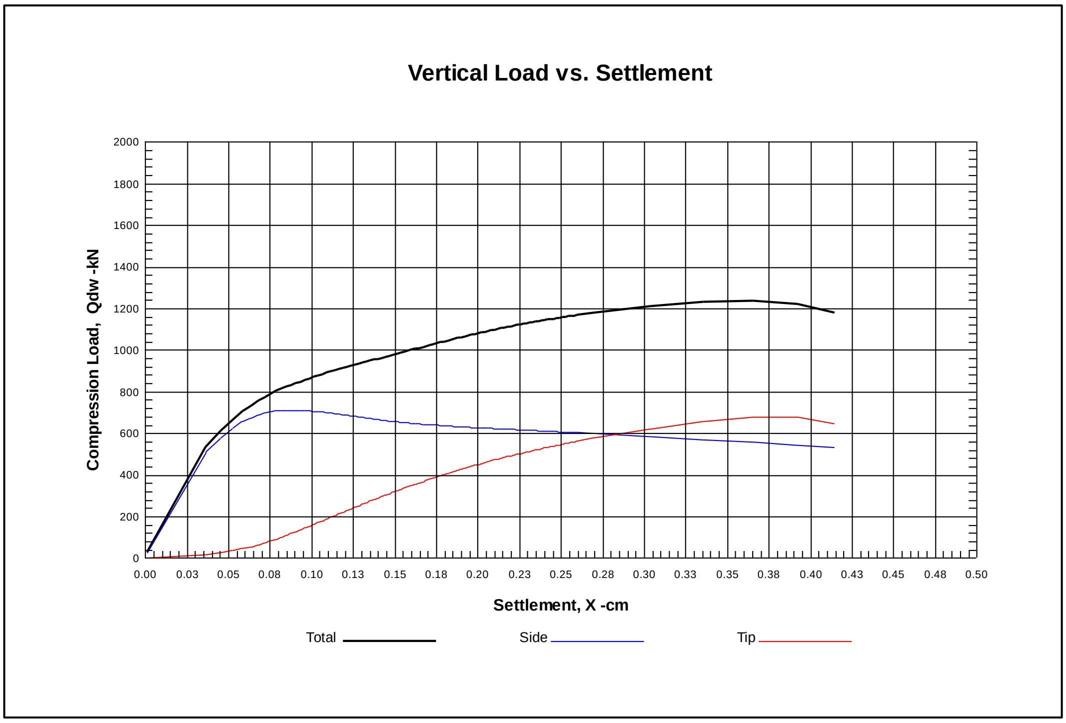


Figure 4-18 Vertical Load vs Total Settlement of Pile SPP 711 T12 mm for Trestle based on BHL-04