CHAPTER II
REVIEW OF LITERATURE

2.1 General Review

Literatures is needed in designing wharf to figure out planning and calculation that will be doing in designing wharf at Paxocean, Batam Island. Besides that, to give knowledge basic theory that will espouse the design of wharf with capacity 20.000 DWT. There are any aspects to be considered that probably will influence the design of wharf. Designing wharf involve any factors such as environment, function of the wharf, loadings, etc. The design of wharf in this thesis will consider any principles as following :

1. Dimension of wharf including length, width, depth and characteristic of wharf to be adjusted with capacity of the ships berthing and mooring at the wharf.
2. Width of the wharf is for operating truck, crane and forklift truck.
3. Loadings should be resisted by wharf, either area loads or distributed loads.

2.2 Definition of wharf

Wharf is a facility of a port that used for mooring ships doing loading and unloading goods or passangers. Shape and dimension of the wharf depend upon type and size of the ships that mooring at the wharf. Wharf must be design and plan properly in order any ships may moor, berth and doing any activities at it safely, quickly and smoothly. (Triatmojo, 2009).

2.3 Shape and Type of Wharf

Shape and type of wharf divided by :

1. Wharf

Wharf is a dock that build parallel with shoreline. In Indonesia, type of this dock is called with type of continuous. Wharf usually used as a dock for goods where needs enough outdoors for guarantee fluency and smoothness goods loading. Type of wharf should be calculate mooring of ships, loading and unloading equipment, and facilities of land transportation. Characteristic of ships that will be mooring and berthing influence the length and depth need for the ships as showing Figure 2.1. (Triatmodjo, 2009).

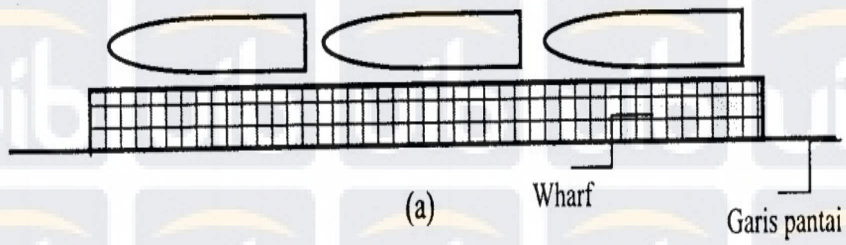

Figure 2.1: Wharf

Source : Perencanaan Pelabuhan Bambang Triadtmodjo, 2009

2. Pier

Pier is a dock almost same with wharf (parallel with shoreline) and its shape is as like as finger and may moor and berth ships at the both side as showing Figure 2.2 (Triatmodjo, 2009).

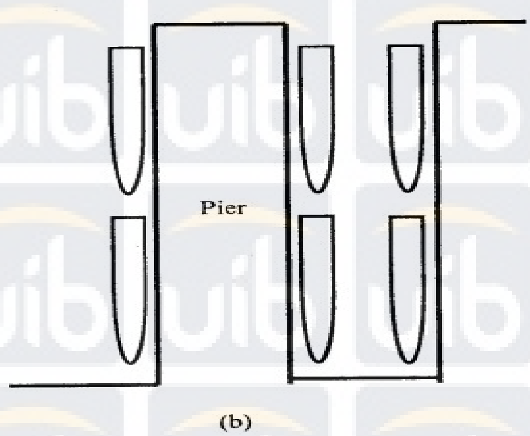

Figure 2.2: Pier

Source : Perencanaan Pelabuhan Bambang Triadtmodjo, 2009

3. Jetty

Jetty is a dock that stick further at the sea to get enough depth for ship mooring and berthing. Generally, jetty is used for mooring and berthing tanker ship, LNG, and coal barge ship as showing Figure 2.3 (Triatmodjo, 2009).

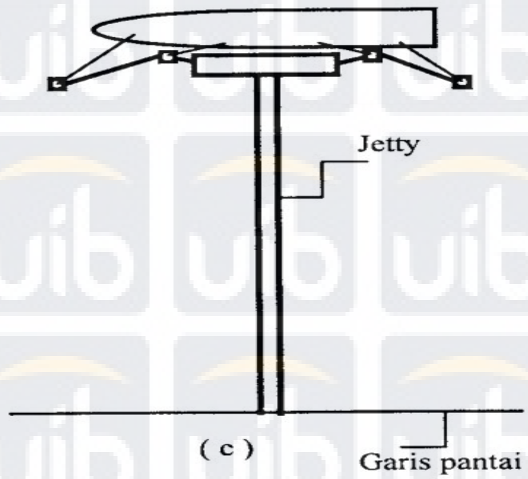

Figure 2.3: Jetty

Source : Perencanaan Pelabuhan Bambang Triadtmodjo, 2009

2.4 Loading

2.4.1 Horizontal Load

Horizontal load is determined based on wind and tidal forces working at the wharf. Horizontal Load consists of :

1. Berthing force
2. Mooring force
3. Loading due to current
4. Loading due to tide
5. Wind force

2.4.1.1 Berthing Force

Berthing force is a forces happens when the ship berth at the wharf with a particular speed (Average: 0.1-0.2 m/s). Berthing force must be resisted by wharf depend on energy absorp by fender system installed at the wharf. Berthing force working horizontally and can be calculated based on berth energy. Correlation between force and berth energy depend on type of fender that using at the wharf.

Berthing energy calculated as following formula :

$$E = \frac{W\,x\,V^2}{2g} Cm\ x\ Ce\ x\ Cs\ x\ Cc$$

Where :

E	= Energy of berthing (ton.m)
W	= Weight of ship (ton)
V	= Velocity of ship (m/sec)
Cm	= Coefficient of hydrodynamic
Ce	= Eccentricity Factor
Cs	= Softness Factor
Cc	= Berth Configuration Factor (1,0)

2.4.1.2 Mooring force

Ship that will move closer to the wharf will be moored by rope to the bollard. This rope will resist ship movement caused by wind and current. Forces that happen at the rope caused by wind and current at the body of the ship is called morring forces. Bollard plant and anchor at the wharf and must be adequate mooring force of the ship. (Triatmodjo, 2009).

2.4.1.3 Loading due to current

Current at sea also must be calculated properly for the wharf because current will cause force at the body of submerged ship then will distribute to the bollard and wharf (Triatmodjo, 2009). The value of loading caused by current can be calculated with following formula :

$$Pc = Cc \times \gamma c \times Ac \times \frac{Vc^2}{2g}$$

Where :

Pc	= Pressure of current at ship (ton)
ɣc	= Density of sea water (=1,025 t/m^3)
Ac	= Area of ship below water level (m^2)
Vc	= Speed of current (m/sec)
Cc	= Coefficient of current (=1)
g	= 9,81 m/s^2

2.4.1.4 Loading due to tide

Tide force that work at the wharf is forces that work and influence the piling system of the wharf. Piling system using for this design is driven pile system. Piling foundation with spacing D hit by tide with length of the tide L where L/D is big.

Based on (Triatmodjo, 2009), tide is classified by 3 types :

a. Shallow sea : $d/L < 1/20$

b. Transition : $1/20 < d/L < 1/2$

c. Deep sea : $d/L > 1/2$

2.4.1.5 Wind Force

Wind force also involved as horizontal load that work at the wharf. Wind speed must be calculated as a load that influence the structure of the wharf. When wind moves towards the dock, then that force will effect as a berthing force to the dock. Meanwhile, wind moves leaving the dock, then that force will effect as a mooring force to the dock.

The value of wind force depend on direction of wind and can be calculated with these following formula :

- Longitudinal force if wind moves from the direction of bow of the ship ($\alpha = 0^\circ$)
  $Rw = 0{,}42 \times Q_a \times A_w$
- Longitudinal force if wind moves from the direction of stern of the ship ($\alpha = 180^\circ$)
  $Rw = 0{,}5 \times Q_a \times A_w$
- Lateral force if wind moves from the direction of the width ($\alpha = 90^\circ$)
  $Rw = 1{,}1 \times Q_a \times A_w$
  $Q_a = 0{,}063 \times V^2$
  Where :
  R_w = Force due to wind (kg)
  Q_a = Wind pressure (kg/m^2)
  V = Velocity of wind (m/s)
  A_w = Wind area (m^2)

2.4.2 Vertical Load

Vertical load consists of dead load and live load.

2.4.2.1 Dead Load

Dead load is structure weight and foundation with all materials involved permanently at the structure of the wharf. Dead load happens due to weight of construction at the building of the wharf. Dead load consist of :

a. Structure load such as slab, pilecap and piling at the wharf
b. Fender force
c. Bollard force

These following is specifiv gravity of any materials on wharf construction:

-) Concrete = 2.400 kg/m^3
-) Steel = 7.850 kg/m^3
-) Rubber = 1.200 kg/m^3

2.4.2.2 Live Load

Live load is a moving load and working at the slab of the wharf. Live load consists of :

1. Area live load

   This wharf is not using for loading or unloading goods or passengers. This wharf is using for repairing ships and live load resist at the slab is 2,5 ton/m^2.

2.5 Design Slab

Table 2.1. Slab Moment Formula

Source : Balok & Pelat Beton Bertulang, Ali Asroni, 2010

	l_y / l_x	1,0	1,1	1,2	1,3	1,4	1,5	1,6	1,7	1,8	1,9	2,0	2,1	2,2	2,3	2,4	2,5	>2,5
I	$Mlx = +0{,}001.q.lx^2.X$	44	52	59	66	73	78	84	88	93	97	100	103	106	108	110	112	125
	$Mly = +0{,}001.q.lx^2.X$	44	45	45	44	44	43	41	40	39	38	37	36	35	34	33	32	25
II	$Mlx = +0{,}001.q.lx^2.X$	21	25	28	31	34	36	37	40	40	40	41	41	41	42	42	42	42
	$Mly = +0{,}001.q.lx^2.X$	21	21	20	19	18	17	16	14	13	12	12	11	11	11	10	10	8
	$Mtx = -0{,}001.q.lx^2.X$	52	59	64	69	73	76	79	81	82	83	83	83	83	83	83	83	83
	$Mty = -0{,}001.q.lx^2.X$	52	54	56	57	57	57	57	57	57	57	57	57	57	57	57	57	57
III	$Mlx = +0{,}001.q.lx^2.X$	28	33	38	42	45	48	51	53	55	57	58	59	59	60	61	61	63
	$Mly = +0{,}001.q.lx^2.X$	28	28	28	27	26	25	23	23	22	21	19	18	17	17	16	16	13
	$Mtx = -0{,}001.q.lx^2.X$	68	77	85	92	98	103	107	111	113	116	118	119	120	121	122	122	125
	$Mty = -0{,}001.q.lx^2.X$	68	72	74	76	77	77	78	78	78	78	79	79	79	79	79	79	79
IVA	$Mlx = +0{,}001.q.lx^2.X$	22	28	34	42	49	55	62	68	74	80	85	89	93	97	100	103	125
	$Mly = +0{,}001.q.lx^2.X$	32	35	37	39	40	41	41	41	41	40	39	38	37	36	35	35	25
	$Mty = -0{,}001.q.lx^2.X$	70	79	87	94	100	105	109	112	115	117	119	120	121	122	123	123	125
IVB	$Mlx = +0{,}001.q.lx^2.X$	32	34	36	38	39	40	41	41	42	42	42	42	42	42	42	42	42
	$Mly = +0{,}001.q.lx^2.X$	22	20	18	17	15	14	13	12	11	10	10	10	9	9	9	9	8
	$Mtx = -0{,}001.q.lx^2.X$	70	74	77	79	81	82	83	84	84	84	84	84	83	83	83	83	83
VA	$Mlx = +0{,}001.q.lx^2.X$	31	38	45	53	60	66	72	78	83	88	92	96	99	102	105	108	125
	$Mly = +0{,}001.q.lx^2.X$	37	39	41	41	42	42	41	41	40	39	38	37	36	35	34	33	25
	$Mty = -0{,}001.q.lx^2.X$	84	92	99	104	109	112	115	117	119	121	122	122	123	123	124	124	125
VB	$Mlx = +0{,}001.q.lx^2.X$	37	41	45	48	51	53	55	56	58	59	60	60	60	61	61	62	63
	$Mly = +0{,}001.q.lx^2.X$	31	30	28	27	25	24	22	21	20	19	18	17	17	16	16	15	13
	$Mtx = -0{,}001.q.lx^2.X$	84	92	98	103	108	111	114	117	119	120	121	122	122	123	123	124	125
VIA	$Mlx = +0{,}001.q.lx^2.X$	21	26	31	36	40	43	46	49	51	53	55	56	57	58	59	60	63
	$Mly = +0{,}001.q.lx^2.X$	26	27	28	28	27	26	25	23	22	21	21	20	20	19	19	18	13
	$Mtx = -0{,}001.q.lx^2.X$	55	65	74	82	89	94	99	103	106	110	114	116	117	118	119	120	125
	$Mty = -0{,}001.q.lx^2.X$	60	65	69	72	74	76	77	78	78	78	78	78	78	78	78	79	79
VIB	$Mlx = +0{,}001.q.lx^2.X$	26	29	32	35	36	38	39	40	40	41	41	42	42	42	42	42	42
	$Mly = +0{,}001.q.lx^2.X$	21	20	19	18	17	15	14	13	12	12	11	11	10	10	10	10	8
	$Mtx = -0{,}001.q.lx^2.X$	60	66	71	74	77	79	80	82	83	83	83	83	83	83	83	83	83
	$Mty = -0{,}001.q.lx^2.X$	55	57	57	57	58	57	57	57	57	57	57	57	57	57	57	57	57

Keterangan : ——— = Terletak bebas
ППППП = Terjepit penuh

Formula to design area of reinforcement as following :

$$As = \frac{0{,}85 \; x \; fc' x \; a \; x \; b}{fy}$$

Where :

As = Area of reinforcement (mm^2)

fc' = Concrete Strength (Mpa)

a = thick of slab stress (mm)

b = length per 1000 mm

fy = Steel strength (Mpa)

For fc' ≤ 31,36 Mpa, $A_{s,u} \geq \frac{1{,}4 \; x \; b \; x \; d}{fy}$

Space :

$$s = \frac{\frac{1}{4} x \; \pi \; x \; D^2 x \; S}{As{,}u}$$

Where :

π = phi (22/7)

D = Diameter of rebar (mm)

S = Length of slab per 1000 mm

As,u = Area of reinforcement (mm^2)

2.6 Design Fender

Fender is designed to resist mooring force. Fender can be calculated as following 3 formulas and taken the highest energy as design force.

Formula :

$$E = \frac{(W1+W2)\ x\ V^2}{2g} x\ K$$

Where :

E = Energy (ton.m)

W1 = Displacement Tonnage (ton)

W2 = Additional tonnage

V = Velocity of ship (m/s)

g = Gravitational acceleration (m/s^2)

K = Factor of Eccentricity

Table 2.2. Design of Ship Velocity

Source : Perencanaan Pelabuhan Bambang Triatmodjo, 2009

Weight of ship (DWT)	Actual Velocity (m/s)	Design Velocity (m/s)
< 10.000 Ton	0,10 – 0,30	0,20
10.000 – 50.000 Ton	0,10 – 0,20	0,15
> 50.000 Ton	0,10 – 0,15	0,15

2.7 Design Bollard

Bollard is used at docks to holds mooring force. Below table is showing the requirement of bollard capacity based on plan vessel.

Table 2.3. Table tractive forces of vessel

Source : Technical Standards and Commentaries for Port and Harbour Facilities in Japan

Ships with a displacement up to : tonnes	Bollard load P: kN	Approximate spacing between bollards: m	Bollard load normal from the berth: kN/m berth	Bollard load along the berth: kN/m
2000	100	10	15	10
5000	200	15	15	10
10000	300	20	20	15
20000	500	20	25	20
30000	600	25	30	20
50000	800	25	35	20
100000	1000	30	40	25
200000	1500	30	50	30
200000	2000	35	65	40

2.8 Design Sheetpile

Connected or semiconnected sheet piles are often used to build continuous walls for waterfront structures that range from small waterfront pleasure boat launching facilities to large dock facilities.

Several types of sheet pile are commonly used in construction: (a) wooden sheet piles, (b) precast concrete sheet piles, and (c) steel sheet piles. Alumunium sheet piles are also marketed.

Sheet pile walls may be divided into two basic categories: (a) cantilever and (b) anchored. In the construction of sheet piles, the sheet pile may be driven into the ground and then the backfill placed on the land side or the sheet pile may be driven into the ground and the soil in front of the sheet pile dredged.

The allowable design flexural stress for the steel sheet piles is as follows :

Table 2.4. The allowable design flexural strees for steel sheet piles

Source : Principles of Foundation Engineering, Braja Das, 2011

Type of Steel	Allowable Stress
ASTM A-328	170 MN/m^2
ASTM A-572	210 MN/m^2

Type of Steel	Allowable Stress
ASTM A-690	210 MN/m^2

Sheetpile is used to resist soil active pressure. Below figures show lateral earth pressure :

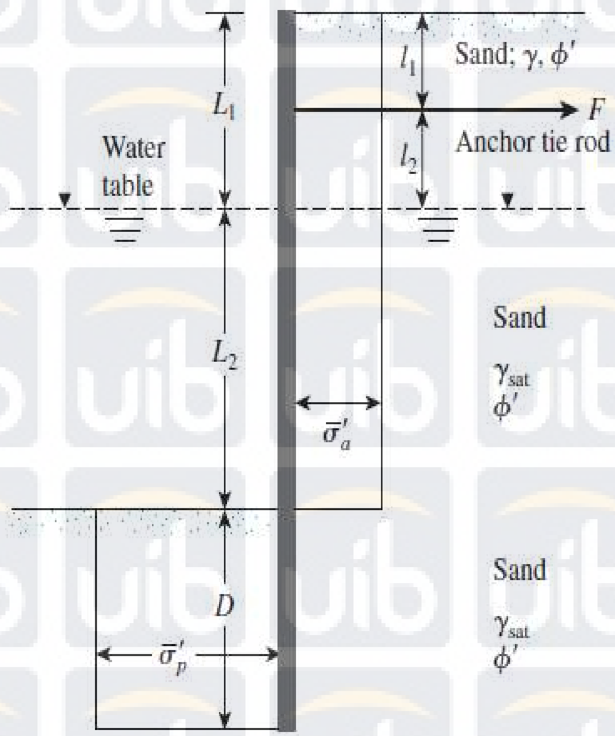

Figure 2.4. Lateral earth pressure on sheet pile

Source : Principles of Foundation Engineering, Braja Das, 2011

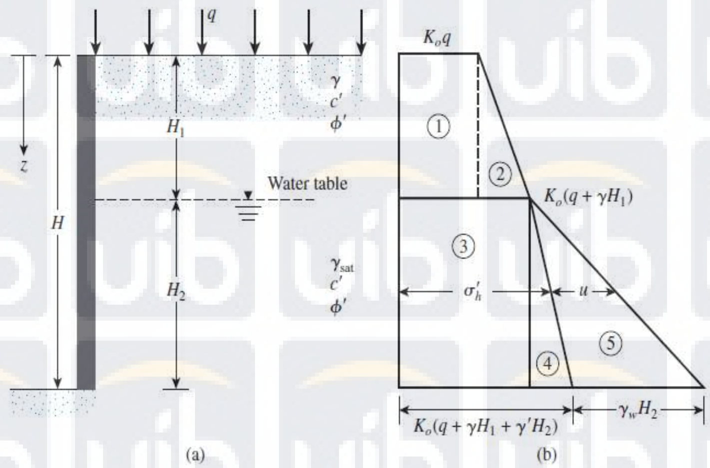

Figure 2.5. At earth earth pressure with water table at a depth z < H

Source : Principles of Foundation Engineering, Braja Das, 2011

Formula to calculate coefficient of active and passive soil pressure as following :

Rankine active earth pressure coefficient (Ka)

Ka $= tg^2 (45 - \phi/2)$

Coulomb's passive earth pressure (Kp)

Kp $= tg^2 (45 + \phi/2)$