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The Identification of Wave Transformation At Poopoh Waters

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Abstract

The Poopoh coast is assumed to have a dynamic process as an effect of wave characteristic transformation, and has led to current generation, abrasion and erosion to the coast. A study to identify the wave transformation at the Poopoh coast is the primary intention. Approach in a way of theoretical and analytical is to analyse the wave transformation at the Poopoh coast area. The wave is forecasted by using the hindcasting method based on the wind record of 12 years from the forecast station of Kayuwatu of the Meteorology, Climatology and Geophysical Agency, in order to obtain a significance of wave height and wave period. The result shows that H = 2.6. m, T = 6.5 sec, and H_o' *= 2.7 m. The refraction coefficient varies from 0.4599 to 1.00013. The shoaling coefficient varies from 0.955 to 1.569. While the wave height after the wave transformation is from 0.6 to 3.385 at the depth of 0.4 m to 3.06 m.*

Keywords — *Poopoh coast, wave transformation*

I. INTRODUCTION

The degraded coast is commonly affected by some natural elements such as coast current, coast sediment transport, the sea level rise and wave. Sea wave is usually generated by wind, tide, current, etc. Sea wave that hits coast is formed by series wave. If a chain of wave moves toward coast, the wave itself will be reformed by wave transformation, so are erosion and abrasion as the effect of wave transformation. This phenomenon will destruct the shoreline and possess a threat to existing infrastructure along the coast.

The Poopoh coast is located at the district of South Minahasa of North Sulawesi province, Indonesia. It has the potential for tourism. At present day, the Poopoh coast has been destructed on its shoreline as the process of coast dynamic took place.

It is suspected that the Poopoh coast has experienced wave transformation causing current generation, abrasion or erosion, sediment transport and shoreline adjustment.

II. AREA OF RESEARCH

The research is located at the Poopoh coast, where the area of research is limited between two points of coordinate as seen in Fig. 1:

Point A = 124º62'72.11" of East Longitude and 01º41'35,13" of North Latitude

Point B = 124º62'89.57" of East Longitude and 01º41'03,09" of North Latitude

The aim of the research is to obtain the wave transformation at the Poopoh coast in the form of refraction, shoaling and breaking wave.

III. METHOD OF DATA COLLECTION

A. Secondary Data

The secondary data collection is carried out by collecting data from its main source. The main source is some related offices which can provide data such as:

a. Wind speed record for the last twelve years. This data is obtained from the Meteorology, Climatology and Geophysical Agency office of Kayuwatu;
b. Map of the research location, obtained from the Microsoft Encarta Premium 2010;
c. Bathymetry map, obtained from the River Basin Organization of North Sulawesi province.

B. Primary Data

The primary data collection is carried out by field surveying in order to acquire data accurately. The identification and listing are the initial process of primary data collection to get the big picture the research location. Visual observation and interview with the community in the coast area are part of the field surveying. While the shoreline destruction, settlement condition to shoreline, social and economic condition and natural phenomenon in the area are listed in inventory.

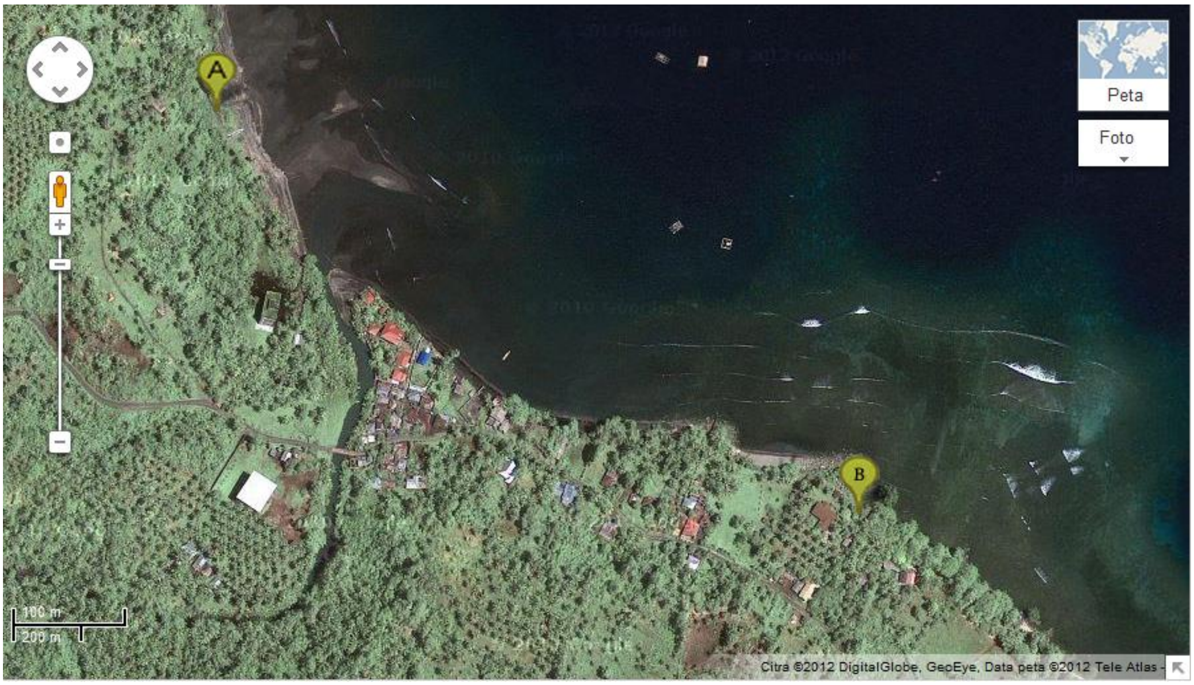

Fig 1: Map of Poopoh Coast

IV. METHOD OF DATA ANALYSIS

A. *Secondary Data Analysis*

a) Wind

The wind data to be analyzed is twelve years of wind data, since 2006 to 2018. It is obtained from the Meteorology, Climatology and Geophysical Agency office of Kayuwatu. They were measured at the elevation of 18 m above sea level. Wind data includes wind speed, wind direction and wind duration. The wind speed data is in knot. The wind direction is in eight points of compass. The wave generation caused by wind is analyzed by using wind data. The shoreline adjustment is analyzed using daily mean wind data.

b) Location Map

The map of research location is obtained from the Microsoft Encarta Premium 2008. The map is required to calculate the effective fetch. The length of effective fetch is determined by drawing lines in radial arrangement from a certain point until each line crosses shoreline. The sum of "i" line on each point of compass covers all of the measurement in the fetch area (20^o on clockwise dan 20^o on counter clockwise).

c) Bathymetry Map

The bathymetry map is obtained from the River Basin Organization of North Sulawesi. It is required to grid division for further calculation.

B. *Primary Data Analysis*

a) Inventoried and Problem Identification

Inventoried and problem identification at the research location provide data as the reference in the analysis process to procure the concept of coast protection that suitable to natural condition and community in the area.

b) Wave Transformation

The analysis of wave transformation has to be adjusted to the situation at Poopoh coast. From visual observation it is known that the coast protection at any kind is unavailable at the coast. Therefore the diffraction and deflection are ignored in the analysis. For effective result, refraction, shoaling and breaking wave are analyzed in eight cross sections on the bathymetry map.

V. RESULT AND DISCUSSION

A. *Effective Fetch*

In Fig. 2, the fetch to North, Northeast and Northwest direction are not limited by the adjacent islands. Therefore it is categorized as "*open water*" (F_{eff}> 100 km). The formed wave is a big wave since it is large area of wave forming. For North direction, the fetch length for angle of -20^o is 717,767 km (based on ENCARTA). The fetch drawing is performed in Fig. 2. The complete fetch length for angle of -20^o to 20^o is presented in Table I.

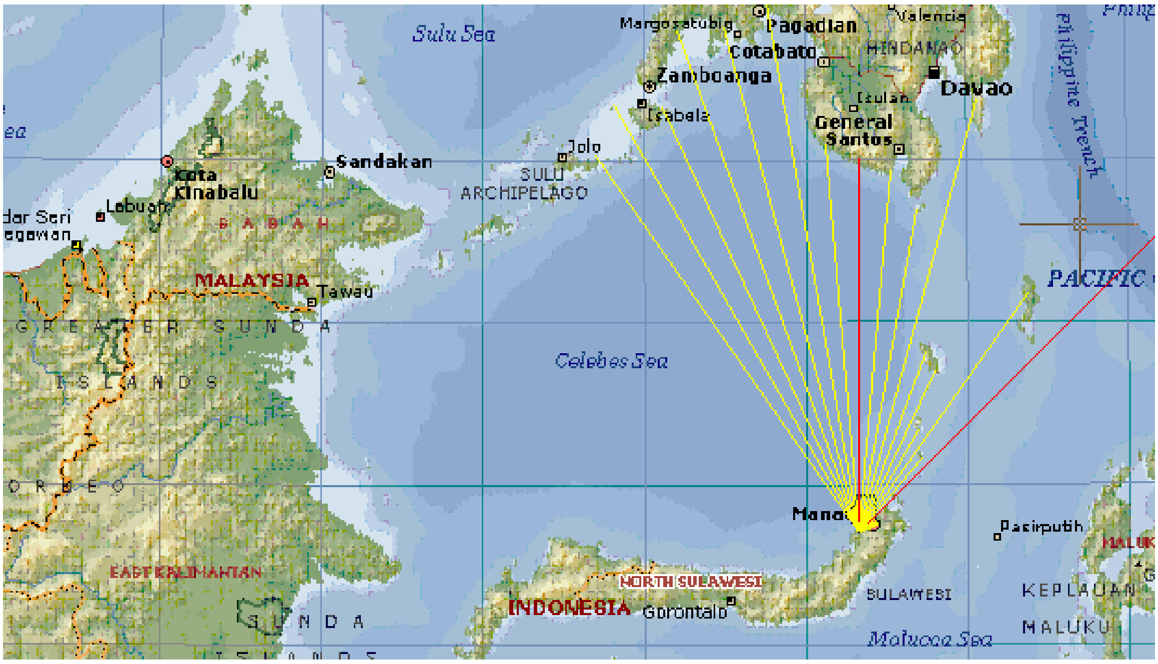

Fig 2: Fetch to Northwest, North and Northeast Direction

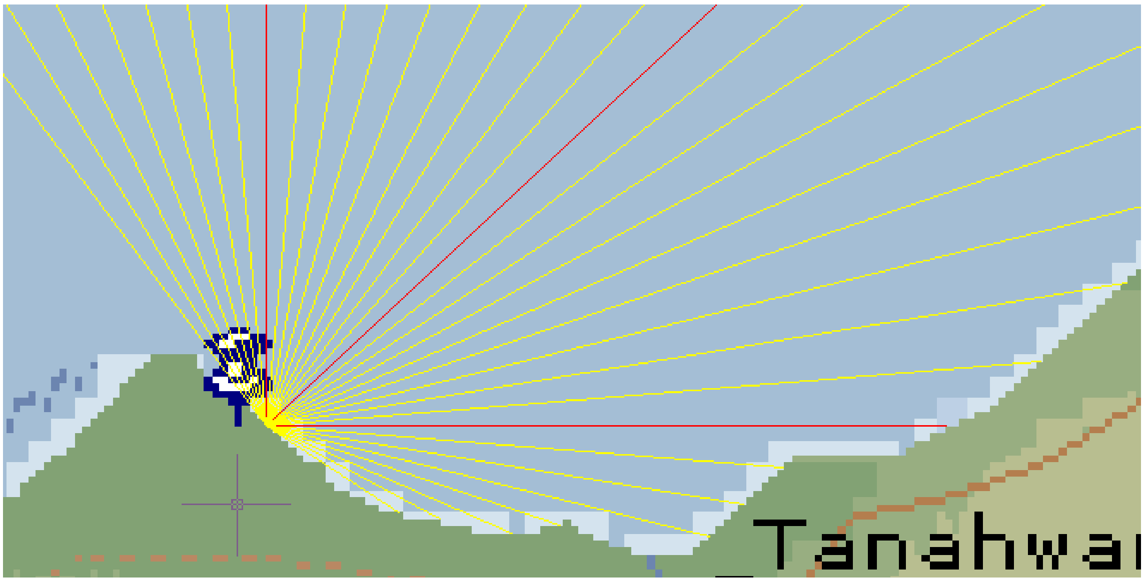

Fig 3: Fetch Detail to Northwest, North, Norteast, East dan Southeast Direction

TABLE I
Fetch Calculation of Eight Points of Compass

Direction	Angle (α) (°)	F(mil)	F(km)	Cos(α)	Fcos(α)	Feff (km)
North	-20.0	446.0	717.767424	0.940	674.481	559.368
	-15.0	442.0	711.330048	0.966	687.092	
	-10.0	455.0	732.25152	0.985	721.127	
	-5.0	334.0	537.520896	0.996	535.475	
	0.0	317.0	510.162048	1.000	510.162	

	5.0	309.0	497.287296	0.996	495.395	
	10.0	271.0	436.132224	0.985	429.506	
	15.0	389.0	626.034816	0.966	604.703	
	20.0	165.0	265.54176	0.940	249.528	
Northeast	-20.0	152.0	244.620288	0.940	229.868	186.739
	-15.0	102.0	164.153088	0.966	158.560	
	-10.0	252.0	405.554688	0.985	399.393	
	-5.0	77.8	125.2069632	0.996	124.731	
	0.0	390.0	627.64416	1.000	627.644	
	5.0	17.0	27.358848	0.996	27.255	
	10.0	16.3	26.2323072	0.985	25.834	
	15.0	16.6	26.7151104	0.966	25.805	
	20.0	16.8	27.0369792	0.940	25.406	
East	-20.0	9.4	15.1278336	0.940	14.216	8.751
	-15.0	8.7	14.0012928	0.966	13.524	
	-10.0	6.7	10.7826048	0.985	10.619	
	-5.0	5.8	9.3341952	0.996	9.299	
	0.0	5.6	9.0123264	1.000	9.012	
	5.0	4.3	6.9201792	0.996	6.894	
	10.0	3.3	5.3108352	0.985	5.230	
	15.0	2.8	4.5061632	0.966	4.353	
	20.0	2.4	3.8624256	0.940	3.629	
Southeast	-20.0	1.9	3.0577536	0.940	2.873	1.101
	-15.0	1.7	2.7358848	0.966	2.643	
	-10.0	1.5	2.414016	0.985	2.377	
	-5.0	1.1	1.7702784	0.996	1.764	
	0.0	0.0	1.609344	1.000	1.609	
	5.0	0.0	0	0.996	0.000	
	10.0	0.0	0	0.985	0.000	
	15.0	0.0	0	0.966	0.000	
	20.0	0.0	0	0.940	0.000	
South	-20.0	0.0	0	0.940	0.000	0.000
	-15.0	0.0	0	0.966	0.000	
	-10.0	0.0	0	0.985	0.000	
	-5.0	0.0	0	0.996	0.000	
	0.0	0.0	0	1.000	0.000	
	5.0	0.0	0	0.996	0.000	
	10.0	0.0	0	0.985	0.000	
	15.0	0.0	0	0.966	0.000	
	20.0	0.0	0	0.940	0.000	
Southwest	-20.0	0.0	0	0.940	0.000	0.000
	-15.0	0.0	0	0.966	0.000	
	-10.0	0.0	0	0.985	0.000	
	-5.0	0.0	0	0.996	0.000	
	0.0	0.0	0	1.000	0.000	
	5.0	0.0	0	0.996	0.000	
	10.0	0.0	0	0.985	0.000	

	15.0	0.0	0	0.966	0.000	
	20.0	0.0	0	0.940	0.000	
	-20.0	0.0	0	0.940	0.000	
	-15.0	0.0	0	0.966	0.000	
	-10.0	0.0	0	0.985	0.000	
	-5.0	0.0	0	0.996	0.000	
West	0.0	0.0	0	1.000	0.000	0.000
	5.0	0.0	0	0.996	0.000	
	10.0	0.0	0	0.985	0.000	
	15.0	0.0	0	0.966	0.000	
	20.0	0.0	0	0.940	0.000	
	-20.0	0.0	0	0.940	0.000	
	-15.0	0.0	0	0.966	0.000	
	-10.0	0.0	0	0.985	0.000	
	-5.0	0.0	0	0.996	0.000	
Northwest	0.0	0.0	0	1.000	0.000	217.799
	5.0	0.0	0	0.996	0.000	
	10.0	392.0	630.862848	0.985	621.279	
	15.0	419.0	674.315136	0.966	651.338	
	20.0	422.0	679.143168	0.940	638.186	

B. *Wind Analysis*

The wind data for analysis are wind speed magnitude and daily maximum wind direction in twelve years since 2006 to 2018. The monthly wind direction in twelve years is classified into eight points of compass. The magnitude of wind speed and its direction are labeled first to perform calculation.

In this calculation, maximum wind speed is used to obtain the extreme waves. The maximum wind speed for significant wave height calculation must be corrected first to attain the wind stress factor. Wind speed is measured by anemometer and in knot.

C. *Wind Stress Factor*

Wind data to forecast wave height and wave period must be corrected first to elevation, stability, location and drag coefficient to obtain the wind stress factor (U_A). The wind data for shore infrastructure design is the daily maximum wind speed that produces maximum wave height.

- Correction to elevation
  Wind data from the Meteorology, Climatology and Geophysical Agency office was measured at the elevation of 18 m above sea level, where $U_{(Z)}$ = 2.0 knot, z = 18 m.

$$U_{(10)} = U_{(z)}\left(\frac{10}{z}\right)^{1/7} = 2.21 \text{ knot}$$

- Correction to stability and location effect
  Since there is no difference between mean temperature in air and on sea, therefore R_T = 1.13 and R_L varies to wind speed (Fig. 4). With $U_{(10)}$ = 2.21 knot, R_L = 1.31, R_T = 1.13, then:
  $U_A = R_T.R_L.U_{(10)}$ = 2.034 m/sec.

D. *Wave Height and Wave Period Hindcasting*

The calculation of wave hindcasting is to obtain H_o and T_o. The calculation by using wind data of North direction in January 1, 2018 is as follow:

- For open water, F_{eff} = 559.368 km = 0.559368 m
  $t_{fetch} = 68{,}8\frac{F^{2/3}}{g^{1/3}\,U_A{}^{1/3}}$ = 172264.749 sec
  t_i = 6 hr (21600 sec)
  Since $t_{fetch} > t_i$ then the wave is on *Duration Limited*
- $H_o = 0{,}0000851\left(\frac{U_A^2}{g}\right)\left(\frac{gt_i}{U_A}\right)$ = 0.059 m
  $T_o = 0{,}0000851\left(\frac{U_A}{g}\right)\left(\frac{gt_i}{U_A}\right)^{0{,}411}$ = 1.688 sec
- Fully developed condition or non fully developed condition :
  Fully Developed,
  $\frac{gH}{U_A^2} \geq 2{,}433.10^{-4}$ ⟶ = 0.326
  $\frac{gT}{U_A} \geq 8{,}134$ ⟶ = 8. 8,1
  $\frac{gt}{U_A} \geq 7{,}15.10^4$ ⟶ = 104072,218

Two out of three criterions above are not met fully developed condition. Therefore the wave is a non-fully developed. The H and T to be used are from previous calculations which are 0.059 m and 1.688 sec. The complete calculation of wind and wave in January 2018 is presented in Table III.

TABLE II
Wind Speed and Wind Direction Data in 2018

Tanggal	Januari		Februari		Maret		April		Mei		Juni		Juli		Agustus		September		Oktober		November		Desember	
	Arah	kec (knots)	Arah	kec (knots)	Arah	kec (knots)	Arah	kec (knots)	Arah	kec (knots)	Arah	kec (knots)	Arah	kec (knots)	Arah	kec (knots)	Arah	kec (knots)	Arah	kec (knots)	Arah	kec (knots)	Arah	kec (knots)
1	B	2.0	BL	6.1	B	2.8	B	5.0	TL	3.2	B	3.0	BD	3.3	T	11.3	BD	5.0	T	4.4	BD	3.1	BD	2.9
2	S	3.0	B	3.5	B	1.6	B	15.2	TL	4.4	TL	4.0	B	7.1	S	10.9	S	6.8	T	4.7	B	3.5	B	2.0
3	TL	1.7	B	1.6	B	1.1	B	9.1	B	1.1	T	1.2	S	15.3	TG	7.8	TG	7.7	T	6.3	T	3.4	U	1.9
4	B	2.9	B	1.4	B	3.1	B	6.3	BD	0.8	S	3.4	S	11.4	T	9.1	T	6.8	TL	5.8	T	4.0	BD	4.2
5	B	3.2	B	2.6	U	5.4	B	3.7	B	1.5	BD	2.1	S	12.1	S	13.4	TL	5.4	T	5.0	TG	2.3	T	5.6
6	BL	2.9	B	1.2	B	3.3	B	5.6	B	1.1	B	1.4	S	8.8	S	11.7	TG	4.1	BD	4.2	S	3.1	B	6.3
7	B	1.6	B	1.8	BD	2.1	B	3.2	U	2.1	T	0.2	S	8.6	S	10.3	T	4.6	S	4.5	S	3.9	U	4.4
8	B	3.0	B	2.0	B	2.2	U	5.4	TL	2.4	S	1.7	T	11.3	T	8.7	T	5.9	TL	5.3	B	3.0	B	3.8
9	B	2.3	BD	1.4	B	1.0	B	3.5	U	2.0	B	0.3	S	6.6	T	8.3	U	3.7	BD	4.2	B	4.8	B	6.4
10	B	1.7	B	3.4	B	1.5	B	5.3	B	2.6	B	1.1	T	5.5	TL	3.4	U	5.9	BD	4.4	B	3.9	BD	4.0
11	B	3.2	T	3.2	S	2.3	B	3.6	B	0.9	B	2.0	T	6.4	TL	4.4	TG	10.0	B	2.2	BD	2.4	B	3.8
12	B	2.7	B	5.0	U	2.3	B	2.4	U	1.5	B	1.7	S	10.0	T	3.5	TG	11.6	B	4.6	B	3.8	U	3.4
13	U	0.8	B	2.9	B	2.6	B	5.9	U	3.1	T	2.8	S	6.2	T	13.3	TG	12.2	TL	3.8	U	2.5	BD	4.4
14	U	1.2	B	2.2	B	0.8	B	3.6	B	1.7	TG	6.2	S	3.3	S	9.5	S	9.9	B	3.2	B	4.3	B	6.9
15	B	2.9	TL	4.1	B	2.4	B	3.4	U	2.0	TG	4.8	S	4.7	U	5.0	S	8.1	B	4.7	B	2.4	B	5.2
16	BL	1.9	T	2.1	U	0.8	B	3.9	BD	2.6	TG	6.5	TG	7.7	B	4.3	T	4.6	T	4.8	S	3.4	B	4.6
17	B	2.6	BD	1.2	BL	0.8	U	2.5	TL	2.2	S	7.1	T	6.5	S	6.5	B	3.6	TG	9.0	U	4.5	B	2.6
18	B	2.7	B	2.9	U	1.1	U	1.5	B	1.6	S	6.2	T	5.2	S	14.5	S	4.4	T	7.2	B	3.4	U	3.2
19	TG	1.6	T	3.1	B	1.6	B	3.0	B	1.6	S	4.7	T	5.9	S	11.5	TL	5.2	S	10.4	U	2.8	BL	2.8
20	B	2.5	BL	2.0	B	2.0	B	2.4	B	1.3	S	4.2	T	4.5	S	15.2	T	4.5	S	5.4	BD	2.9	B	2.9
21	B	2.5	B	2.0	B	2.0	U	3.8	T	1.5	S	7.7	T	5.6	S	14.7	T	5.1	T	4.9	BD	3.3	B	1.5
22	U	1.2	B	2.0	U	1.4	B	2.1	B	1.4	S	12.1	T	5.0	S	16.4	S	4.0	TG	4.4	U	3.1	B	2.3
23	B	3.3	B	2.6	TG	1.3	T	1.8	B	1.4	S	8.9	T	8.4	S	16.0	TL	5.3	T	3.5	U	2.0	B	5.0
24	B	2.0	B	3.7	B	0.7	B	2.8	BD	2.5	T	7.2	T	11.1	S	18.6	TL	3.8	TL	4.2	TG	3.5	BL	1.2
25	B	3.8	B	5.4	B	3.2	BL	2.5	B	2.5	T	6.5	T	4.7	S	16.4	B	10.4	TG	5.6	B	4.0	B	4.1
26	B	2.5	B	2.6	B	4.4	B	0.9	BD	1.5	T	8.0	S	10.1	TG	16.4	TG	12.5	T	3.8	T	2.4	B	2.3
27	S	0.6	B	0.3	B	4.5	B	2.5	B	0.8	B	5.2	S	12.5	TG	13.1	BD	7.4	T	3.8	BL	2.6	B	3.3
28	B	2.9	B	2.1	B	2.4	U	1.5	B	1.2	S	6.5	S	15.8	T	9.9	BD	4.5	T	4.9	TL	3.2	B	3.1
29	B	1.2			B	4.0	U	0.8	TL	3.1	U	8.9	T	10.4	T	5.5	TG	6.1	U	3.8	B	1.4	U	2.9
30	BD	1.4			B	4.7	T	1.4	BL	1.8	S	4.4	T	8.7	TG	8.9	T	4.9	B	3.2	TG	3.5	U	5.0
31	U	0.2			B	3.6			U	2.2			T	5.7	B	3.6			U	3.8			U	2.9

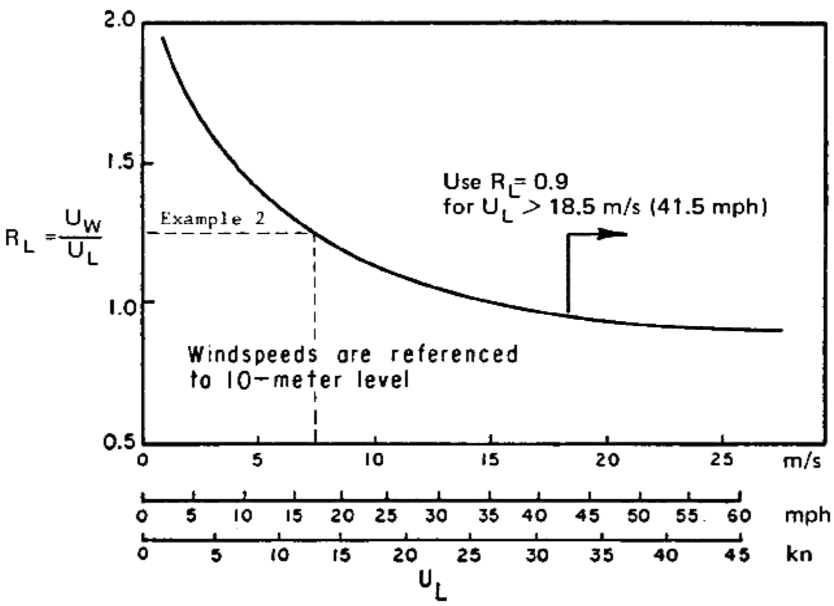

Fig 4: Determination of R_L

TABLE III
Hindcasting Calculation for Maximum Wave in January 2018

Date	Direction	U_z Max	U_{10}	R_L	U_A		F_{EFF}	t_i	Open Water atau Restricted Fetch	t_{FETCH}
		knot	knot		knot	m/sec	km	Sec.		Sec.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(9)	(8)	(10)	(11)
1	U	2.0	1.84	1.90	3.95	2.034	559.368	21600	Open Water	172264.749
2	S	3.0	2.76	1.80	5.62	2.896	0.000	21600	-	-
3	TL	1.7	1.56	1.93	3.41	1.758	186.739	21600	Open Water	87035.396
4	B	2.9	2.67	1.81	5.46	2.813	0.000	21600	-	-
5	B	3.2	2.94	1.79	5.94	3.058	0.000	21600	-	-
6	BL	2.9	2.67	1.81	5.46	2.813	217.799	21600	Open Water	82440.551
7	B	1.6	1.47	1.94	3.23	1.663	0.000	21600	-	-
8	B	3.0	2.76	1.80	5.62	2.896	0.000	21600	-	-
9	B	2.3	2.11	1.87	4.47	2.302	0.000	21600	-	-
10	B	1.7	1.56	1.93	3.41	1.758	0.000	21600	-	-
11	B	3.2	2.94	1.79	5.94	3.058	0.000	21600	-	-
12	B	2.7	2.48	1.83	5.14	2.646	0.000	21600	-	-
13	U	0.8	0.74	2.03	1.69	0.871	559.368	21600	Open Water	228538.461
14	U	1.2	1.10	1.99	2.48	1.276	559.368	21600	Open Water	201213.594
15	B	2.9	2.67	1.81	5.46	2.813	0.000	21600	-	-
16	BL	1.9	1.75	1.91	3.77	1.943	217.799	21600	Open Water	93269.169
17	B	2.6	2.39	1.84	4.97	2.561	0.000	21600	-	-
18	B	2.7	2.48	1.83	5.14	2.646	0.000	21600	-	-
19	TG	1.6	1.47	1.94	3.23	1.663	1.101	21600	Open Water	2892.624
20	B	2.5	2.30	1.85	4.81	2.476	0.000	21600	-	-
21	B	2.5	2.30	1.85	4.81	2.476	0.000	21600	-	-
22	U	1.2	1.10	1.99	2.48	1.276	559.368	21600	Open Water	201213.594
23	B	3.3	3.03	1.78	6.09	3.138	0.000	21600	-	-
24	B	2.0	1.84	1.90	3.95	2.034	0.000	21600	-	-
25	B	3.8	3.49	1.74	6.85	3.528	0.000	21600	-	-
26	B	2.5	2.30	1.85	4.81	2.476	0.000	21600	-	-
27	S	0.6	0.55	2.06	1.28	0.661	0.000	21600	-	-
28	B	2.9	2.67	1.81	5.46	2.813	0.000	21600	-	-
29	B	1.2	1.10	1.99	2.48	1.276	0.000	21600	-	-
30	BD	1.4	1.29	1.97	2.86	1.472	0.000	21600	-	-
31	U	0.2	0.18	2.11	0.44	0.226	559.368	21600	Open Water	358395.803

Wave Condition	$H_{0(i)}$	$T_{0(i)}$	gH/U_A^2	gT/U_A	gt_i/U_A	"Fully or Non Fully Developed"	H_0	T_0
	m	Sec.					m	Sec.
(12)	(13)	(14)	(15)	(16)	(16)	(17)	(18)	(19)
Duration Limited	0.138	1.681	0.326	8.100	104072.218	Fully Developed Sea	0.050	1.688
-	-	-	-	-	-	-	-	-
Duration Limited	0.114	1.543	0.362	8.601	120436.050	Fully Developed Sea	0.044	1.459
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
Duration Limited	0.209	2.035	0.259	7.089	75240.500	Fully Developed Sea	0.070	2.335
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
Duration Limited	0.046	1.020	0.598	11.477	243009.618	Fully Developed Sea	0.022	0.723
Duration Limited	0.076	1.278	0.455	9.809	165850.783	Fully Developed Sea	0.032	1.059
-	-	-	-	-	-	-	-	-
Duration Limited	0.130	1.636	0.337	8.254	108954.042	Fully Developed Sea	0.048	1.613
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
Fetch Limited	0.028	0.763	0.100	4.496	127251.138	Fully Developed Sea	0.041	1.381
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
Duration Limited	0.076	1.278	0.455	9.809	165850.783	Fully Developed Sea	0.032	1.059
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
Duration Limited	0.008	0.461	1.569	19.988	937204.389	Fully Developed Sea	0.006	0.187

The wave hindcasting is conducted for twelve years to each maximum wind data. The result is sorted in the form of maximum wave period, maximum wave direction and monthly dominant from 2006 to 2018. This is to attain maximum and dominant data of each point of compass to be the reference of the design wave.

The results in Table V show that the dominant and maximum wave come from North direction. It is because of larger area of wave generation in North. Wave hindcasting. Wave hindcasting from daily maximum wind data will produce a high wave and an extreme wave period. This maximum wave is used in the coast infrastructure design, whether to define wave with return period or to determine detail engineering design.

E. Wave Transformation

The procedure to perform wave transformation calculation is as follow:

- Define the angle of approaching wave (α), a angle of 45^o is taken
- Define the depth (d) to recognize the wave height adjustment caused by shoaling. A depth between -25 m to -0.5 m is taken
- Define the wave height and design wave period which are the maximum in wave direction.

The relation chart between maximum wave height and maximum wave period within twelve years based on the result of hindcasting method is set to determine the maximum wave period (Fig. 5).

TABLE IV
Max. Wave Height, Max. Wave Period, Max. Wave Direction and Monthly Dominant based on The Wave Hindcasting for 2006 to 2018

No	Month	H & T	Wave Direction					Max of each month	
			NW	N	NE	E	SE	Direction Dominant	H - T
1	January	H(m)	0.5889	1.3550	0.4091	0.3010	0.0413	N	1.3550
		T(dt)	3.2701	4.7902	2.7674	2.3738	1.3807		4.7902
2	February	H(m)	0.4533	2.6006	0.6785	0.2455	0.0674	N	2.6006
		T(dt)	2.9006	6.4576	3.4894	2.3816	2.2542		6.4576
3	March	H(m)	0.5889	1.9386	0.5679	0.2104	0.0571	N	1.9386
		T(dt)	3.2701	5.6445	3.2162	2.1068	1.9104		5.6445
4	April	H(m)	1.0506	1.3550	1.0506	0.3541	0.0505	N	1.3550
		T(dt)	4.2632	4.7902	4.2632	2.5060	1.6882		4.7902
5	May	H(m)	0.8584	1.6453	0.3261	0.4721	0.1164	N	1.6453
		T(dt)	3.8864	5.2358	2.4944	2.7582	1.3017		5.2358
6	June	H(m)	0.7259	1.2354	0.5679	0.3010	0.1506	N	1.2354
		T(dt)	3.5989	4.5918	3.2162	2.3738	1.3340		4.5918
7	July	H(m)	0.3717	1.3550	0.3030	0.3866	0.1386	N	1.3550
		T(dt)	2.6485	4.7902	2.4120	2.5804	1.2976		4.7902
8	August	H(m)	0.0000	0.6580	0.3261	0.4339	0.2116	N	0.6580
		T(dt)	0.0000	3.4407	2.4944	2.6817	1.9830		3.4407
9	September	H(m)	0.5889	1.3550	0.5959	0.3541	0.1498	N	1.3550
		T(dt)	3.2701	4.7902	3.2878	2.5060	2.3007		4.7902
10	October	H(m)	1.3550	1.6453	0.8584	0.2783	0.1164	N	1.6453
		T(dt)	4.7902	5.2358	3.8864	2.3127	1.2241		5.2358
11	November	H(m)	1.0506	0.8584	0.7259	0.3541	0.1899	NW	1.0506
		T(dt)	4.2632	3.8864	3.5989	2.5060	1.4413		4.2632
12	December	H(m)	1.0506	1.8195	0.0719	0.4035	0.0723	U	1.8195
		T(dt)	4.2632	5.4829	2.4035	2.6174	2.4035		5.4829
Max. at each direction		H(m)	1.3550	2.6006	1.0506	0.4721	0.2116		
		T(dt)	4.7902	6.4576	4.2632	2.7582	2.4035		

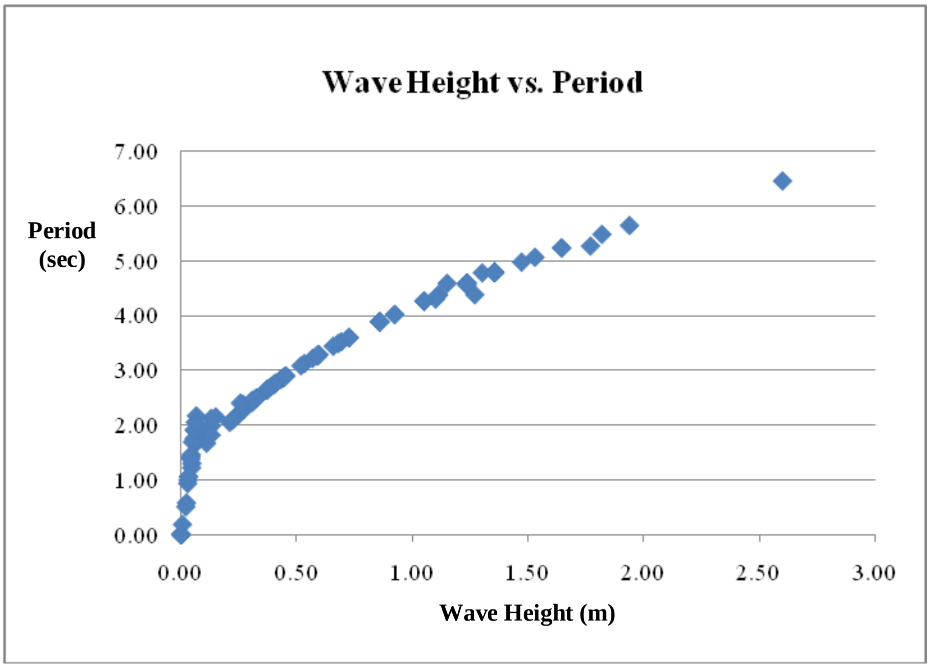

Fig 5: Relation between Wave Height and Wave Period

A relation of H and T from the chart is defined by equation:

$y = -0{,}468x^2 + 3{,}357x + 1{,}507$

For North direction :

H_o = 2.6006 m

T_o = $-0.468.H_o^2 + 3.357.H_o + 1.507$

= 7.0721 sec

L_o = $1{,}56\ T^2$

= 78.022 m

d/L_o = 25/78.022

= 0.32

Find d/L from d/L_o = 0.320 (Table V)

TABLE V
Pembacaan Nilai d/L dan n

$\frac{d}{L_0}$	$\frac{d}{L}$	$\frac{2\pi d}{L}$	tanh $2\pi d/L$	sinh $2\pi d/L$	cosh $2\pi d/L$	K_s	K	$\frac{4\pi d}{L}$	sinh $4\pi d/L$	cosh $4\pi d/L$	n
0.3200	0.33025	2.0750	0.9690	3.9196	4.0452	0.955	0.2472	4.1501	31.711	31.73	0.5654
0.3210	0.33116	2.0808	0.9693	3.9429	4.0677	0.956	0.2458	4.1615	32.077	32.09	0.5649
0.3220	0.33208	2.0865	0.9697	3.9663	4.0904	0.956	0.2445	4.1730	32.447	32.46	0.5643
0.3230	0.33299	2.0922	0.9700	3.9898	4.1132	0.956	0.2431	4.1845	32.822	32.84	0.5637
0.3240	0.33391	2.0980	0.9703	4.0135	4.1362	0.957	0.2418	4.1960	33.202	33.22	0.5632

For d/L_0 = 0.3200, d/L = 0.3303 thus L = 75.70 m.

The wave propagation is:

C_o = L_o / T

= 78.022/7.0720

= 11.032 m/det

C = L / T

= 75.70/ 7.0720

= 10.704 m/sec

$$\sin\alpha = \frac{C}{Co}\sin\alpha_o$$

= 0.963

α = 74.367°

The coefficient of refraction is:

$$Kr = \sqrt{\frac{\cos\alpha_o}{\cos\alpha}}$$

= 0.6725

The complete Kr is presented in Table VI.

TABLE VI
Refraction Calculation at Cross Section 4 of North Direction

a_o	d	Ho	T	Lo	d/Lo	d/L	L
45	25	2.6006	7.0721	78.022	0.320	0.3303	75.700
74.367	20	1.6703	5.8084	52.631	0.380	0.3860	51.815
71.454	15	1.4937	5.4772	46.800	0.321	0.3312	45.295
66.576	10	1.2776	5.0320	39.502	0.253	0.2705	36.970
59.180	5	1.0500	4.5159	31.814	0.157	0.1891	26.435
45.528	1	0.8194	3.9436	24.261	0.041	0.0844	11.846
20.391	0.5	0.7485	3.7576	22.026	0.023	0.0620	8.065
7.329	0.1	0.8712	4.0763	25.922	0.004	0.0253	3.953

C	C_o	sin α	α	cos α_o / cos α	Kr
10.704	11.032	0.963	74.367	0.4522	0.6725
8.921	9.061	0.948	71.454	0.8472	0.9204
8.270	8.544	0.918	66.576	0.8001	0.8945
7.347	7.850	0.859	59.180	0.7759	0.8809
5.854	7.045	0.714	45.528	0.7313	0.8552
3.004	6.152	0.348	20.391	0.7474	0.8645
2.146	5.862	0.128	7.329	0.9451	0.9721
0.970	6.359	0.019	1.115	0.9920	0.9960

TABLE VII
Coefficient of Shoaling Calculation

Lo	L	Ks	Kr	H
78.022	75.700	0.955	0.6725	1.670
52.631	51.815	0.972	0.9204	1.494
46.800	45.295	0.956	0.8945	1.278
39.502	36.970	0.933	0.8809	1.050
31.814	26.435	0.913	0.8552	0.819
24.261	11.846	1.057	0.8645	0.749
22.026	8.065	1.197	0.9721	0.871
25.922	3.953	1.818	0.9960	1.578

E. Coefficient of Shoaling

The coefficient of shoaling is:

$$Ks = \sqrt{\frac{n_o L_o}{nL}}$$

From Table V for d/L_o = 0.320, n = 0.5654. Thus:

$$Ks = \sqrt{\frac{0{,}5.78{,}022}{0{,}565.75{,}7}}$$

$$Ks = 0{,}955$$

The wave height is :

H = Ho.Kr.Ks = 1.67 m

G. Breaking Wave

A chart of relation between H_o'/gT^2 and H_b/H_o' (Fig. 6) is used to calculate the breaaking wave. Therefore:

H_o = H_o / (Ks)
= 2.723 m
H_o'/gT^2 = 0.0056
From Fig. 6 :
H_b/H_o' = 1.31
H_b = 3.5685 m

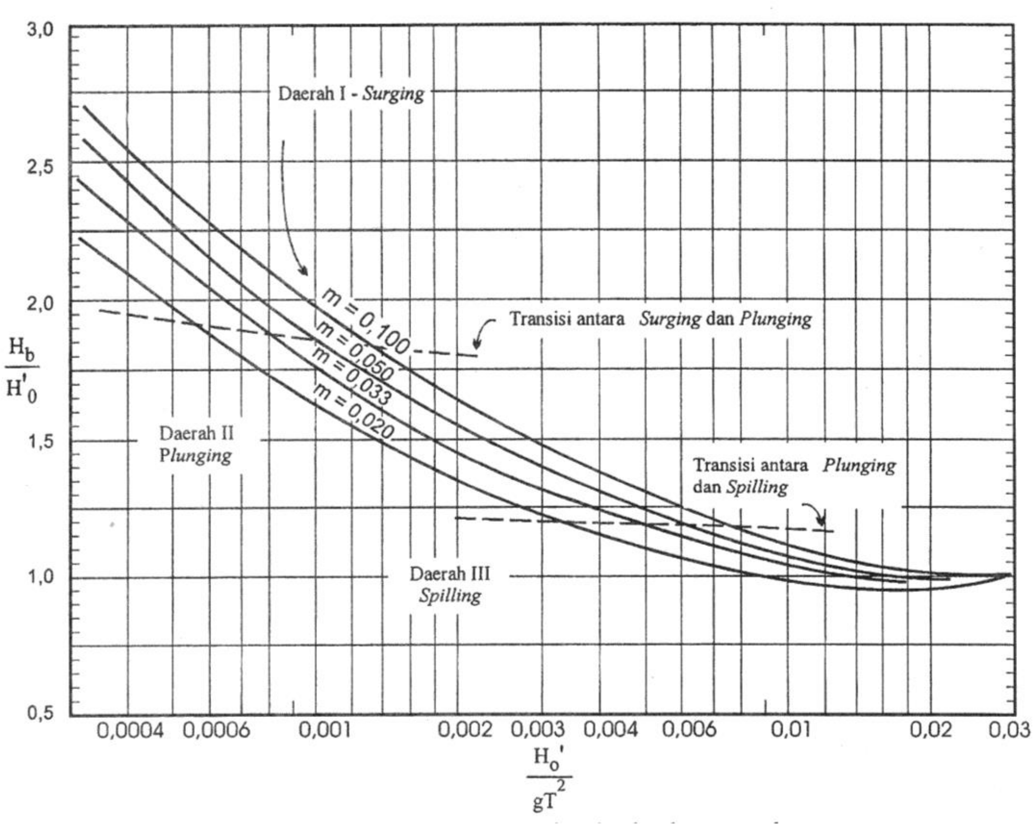

Fig 6: Chart of H_o'/gT^2 vs H_b/H_o'

TABLE IX
The Calculation of Breaking Wave

H_o'	$H_o'/gT^{\wedge 2}$	m	H_b/H_o	H_b
2.723	0.0056	0.1177	1.243	3.573
1.718	0.0052	0.1177	1.288	2.213
1.562	0.0053	0.1177	1.275	1.992
1.369	0.0055	0.1177	1.255	1.719
1.150	0.0057	0.1177	1.231	1.416
0.774	0.0051	0.1177	1.301	1.006
0.630	0.0045	0.1177	1.326	0.835
0.488	0.0030	0.1177	1.563	0.762

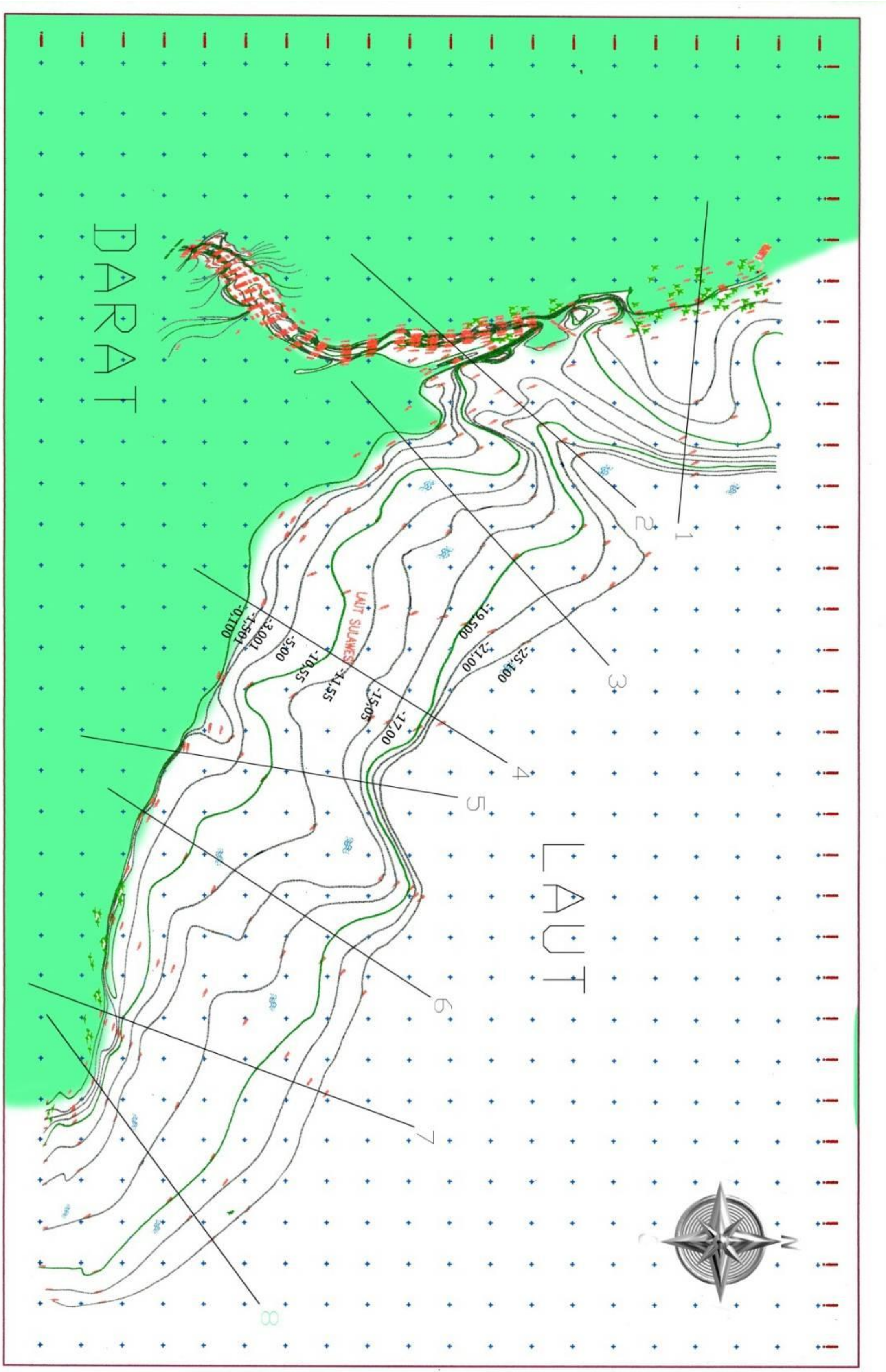

Fig 7: Sections at Research Area

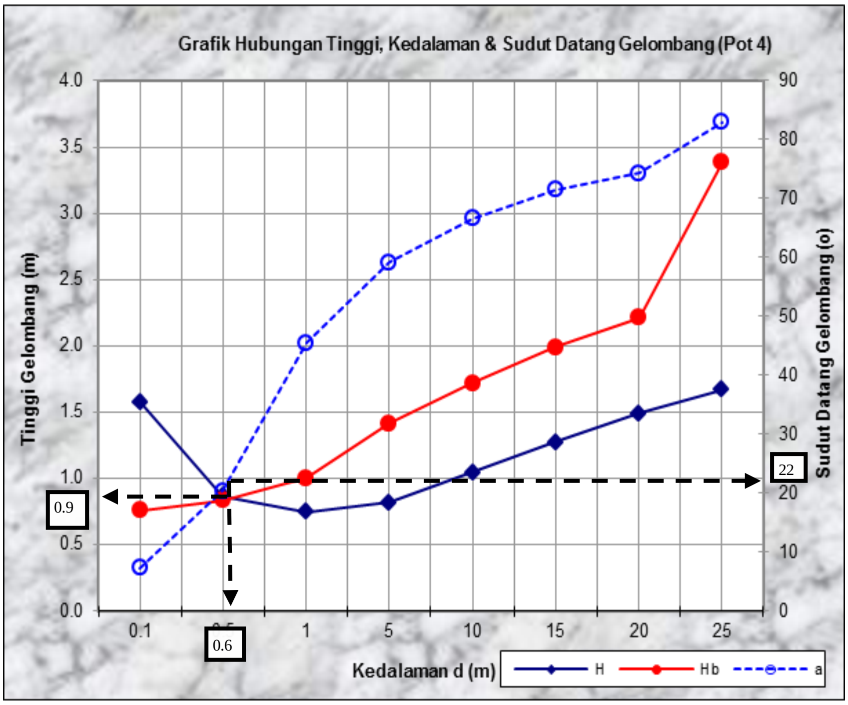

Fig 8: Chart of Wave Height, Depth of Wave and Angle of Approaching Wave at Section 3

Based on chart in Fig. 8, the breaking wave height and the depth of wave are :

Height of Breaking Wave = 0.9 m
Depth of Breaking Wave = 0.6 m

H. Discussion

The analysis with hindcasting method has presented result that the maximum wave comes from North direction, where the height (H_o) is 2.6 m and wave period (T_o) is 6.5 second.

Based on the analytical method, the coefficient of refraction varies from 0.4599 to 1.00013, while the coefficient of shoaling varies from 0.955 to 1.569. It is obvious that the wave height analysis with high value of Kr (varies from 0.8899 to 1.00013) and a value of Ks lower than 0.9 generating a breaking wave height higher than height of approaching wave.

Also from analytical result that the wave height varies from 0.6 m to 3.385 m at the depth from 0.4 m to 2.3 m. The maximum wave height of 3.385 m occurs at the depth of 1.2 m at the distance of 46.4 m to shoreline. Such a wave causes current generation to furthermore cause erosion and abrasion.

VI. CONCLUSION

The identification of wave transformation at the Poopoh waters with the past wind records and the location map concludes that the dominant wave direction is North. It occurs on February 2007 at the wave height of 2.6 m and the wave period of 6.5 seconds.

The wave type is categorized as sea wave with 75.7 m of wave length. The analytical result presents that the coefficient of refraction varies from 0.4599 to 1.00013 and coefficient of shoaling varies from 0.955 to 1.569. The wave height analysis at a high value of Kr and a value of Ks lower than 0.9 causes the breaking wave height higher than the approaching wave height. The wave height varies from 0.6 m to 3.385 m at the depth from 0.4 m to 2.3 m.

The wave transformation analysis of Poopoh coast with twelve years of wind data results the maximum height of breaking wave (H_b) is 3.385 m at the depth of (D_b) of 1.2 m, at the distance of 46.4 m to shoreline. An energy release driven by the breaking wave and the current generation causes erosion and abrasion to the Poopoh coast. This phenomenon is the basis of shoreline destruction at the Poopoh coast.

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