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Sedimentation Evaluation at Water Intake Gate of Grati PLTGU Jetty Blockade

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***Abstract*- Jetty for water intake channel of PLTGU (Air and Gas Electrical Power) basically was designed as a construction which would minimize the problem of sedimentation. There was very much sedimentation at Grati PLTGU. The aim of this study was to evaluate sedimentation problem jetty water intake channel of Grati PLTGU and to find the dimension of jetty construction with sediment degree was lower than the existing construction. Location of study was at Pasuruan, East Java of Indonesia. It was hoped to get dimension of jetty construction which had low sediment level compared to existing construction. Evaluation of water intake channel used the software of SMS 10.1.8. Based on the evaluation of wave and stream, there were 2 designs of jetty modification as follow: 1) Modification of Jetty-I: it was straight upright designed or with angle of 45^0 to the direction of east-north, jetty in the right side was lengthened until 178 m with diameter of curve was 150 m, jetty in the left side followed the projection of jetty length in the right side due to the angle of 45^0; 2) Modification of jetty-II: it followed the design of jetty-I but jetty in the right side was placed at the distance of 20 m from breaking wave.**

***Keywords*- jetty, sedimentation, water intake channel**

I. INTRODUCTION

Sedimentation occurred usually from soil erosion in at catchment area. The sedimentation level of severity was depending on the type of soil, topography, rainfall intensity, and vegetation cover. From an economics perspective reservoir were assets that provided services across a period of time. While sedimentation reduced the storage volume, it also reduced the benefits that could be derived from services provided by the reservoir over time and ultimately shortened its economics life [1]. The quantitative understanding of hydrodynamic and sediment transport on intertidal mudflats were important for the management of estuaries and environmental protection [2]. The sediment transport and hydrodynamics on the mudflats were influenced by processes with a range of times scales due to freshwater discharge, tides, and wind waves their interactions [3].

Nowadays, jetty was more used as coastal safety at industry that used sea water for their need. Beside as breaking wave utilization, jetty was also used for water intake channel as water channel in the direction to industry.

Therefore, the design had to be free of sedimentation. There were many jetty constructions at Indonesia that was used as water intake channel of industry. One of them was Grati PLTGU (Air and Gas Electrical Power), Pasuruan of Indonesia. Planning of jetty which was used for water intake channel of PLTG was basically designed as construction that would minimize the problem of sedimentation. There was so much sedimentation at water intake channel of Grati PLTGU. It could be seen at the activity of operation and maintenance that was sediment dredging in intake direction of Grati PLTGU.

Based on the problem as above, it was suspected that the sedimentation at water intake channel of Grati PLTGU was caused by inaccuracy in design. This design was related to the length, width, and located angle of construction to the direction of coming wave. Hence, it was necessary to accurately evaluate and improve fitted to existing condition. To know the quantity of sediment due to the new design of jetty construction, it was needed accurate modelling to detect the effect of design change of jetty construction. Nowadays, updated software modelling was SMS 10.1.8 (Surface Water Modelling System) which could be simulated occurred sedimentation due to construction design after changes.

II. MATERIALS AND METHODS

This research was as literature study. Data used in this study were collected from PT Indonesia Power Unit Bisnis Pembangkitan (UBP, Indonesian Power Unit of Generation Business). Location was at Perak-Grati, Wates Village, Lekok District, Pasuruan Regency, and East Java of Indonesia. The PLTGU was located at about 30 km from Pasuruan City and it was included Perak PLTU (Air Electrical Power) at Surabaya and Grati PLTGU (Air and Gas Electrical Power). Perak PLTU and Grati PLTGU had a distance of ± 90 km to each other; total of installed capacity for both of them was 864.08 MW

Jetty was a construction which was straight upright at coast and located at both sides of estuary. This construction was functioned for decreasing the groove shallowing of the both sides by coastal sediment. The usage of river estuary as sailing groove and sedimentation at estuary could disturb the coastal traffic.

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To accommodate this need, jetty had to be long until the edge was outside of breaking wave [4][5]. Sediment transport of coast was held due to long jetty and sailing line at wave condition was not broken so that was possible for the ship bewitch to estuary of the river. Jetty could also be used to prevent the shallowing at estuary due to flood control. Rivers which emptied into sandy coast with big enough of wave often went through estuary closing by sandy sediment. Because of the influence of wave and wind, sandy sediment was formed at estuary. Sediment transport along the coast was also very influenced to the sediment forming. Sand that went through in front of estuary would be pushed enter to estuary by wave and then it was precipitated. The very big sediment could cause river estuary was closed [6].

According to the function of jetty which was only for flood control, there were some kinds of jetty due to the dimension as follow and as presented as in Figure 1 below: [6]

a. Long Jetty:

Long jetty had the end outside of breaking wave. This type was effective to prevent entering sediment to estuary, but cinstruction cost was so expensive. Therefore if the function was only for flood control, the usage of this type was not economic unless if the area that had to protect was very important.

b. Medium jetty:

Medium jetty had the end between the ebb of water level and location of breaking wave. This type of jetty was intended to hold part of sediment transport along the coast. Groove at jetty end was still possible being occur sandy sediment.

c. Short jetty:

Short jetty had end of structure at the ebb of water level. The main function of the structure was to hold being turned of river estuary and to concentrate the current at remained groove for scratching sediment, so that at the beginning of rainy season which flood had not been occured, the estuary of river had been opened.

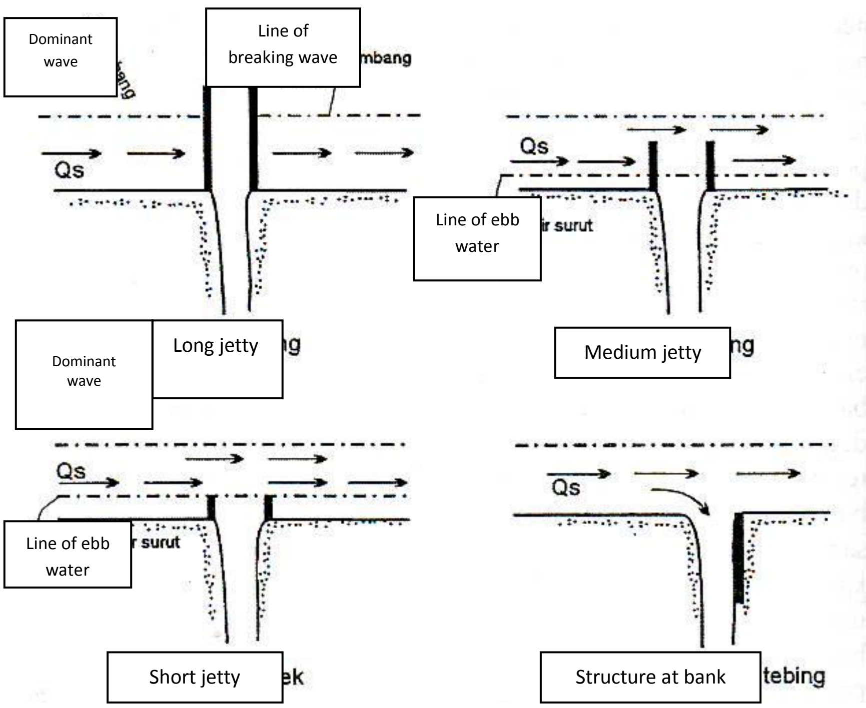

FIG. 1 SOME TYPES OF JETTY [6]

Design of jetty generally was used trapezoidal shape as design of groin or breakwater. But it could also be used sheet pile from steel or wood which in general it was due to available material at borrow area. The steps which were used for design of jetty were as follow: [7][8]

1. To analize generation of wave for determining height and period of wave based on corrected of wind tension factor.
2. To analyze length of fetch from topography map.
3. To analyze rose wave which gave interpretation of wave data frequency according to the direction group and classification of wave height in precentage of wave number.
4. To analize data of yearly significant wave using the method of JONSWAP
5. To analyze design wave for determining wave height with certain return period.
6. To analyze SMS model of ADCIRC
7. To analize refraction and breaking of wave using model of CMS-WAVE and ST-WAVE
8. To control the height of Run Up
9. Modification pattern of jetty
10. To calculate sediment using model of PTM.

III. Results And Discussion

Data that were collected in this study included data of bathymetry, wind, existing jetty design, ebb tidal, sediment, and stream. Data of bathymetry was classified into shallow water (until the depth of 5 m) and deep water (the depth in the range of 2 to 20 m). In general, base slope of coast was not steep. It could be seen when there was ebb water that was coastal wave could reach not less than 1 km from coastal line of normal water. Result of bathymetry by sounding indicated that bed coast at the location started from coastal line until the direction of 2,500 m was not steep, that was reaching the elevation of -2.50 m. But after that, bed slope was much steeper.

Analysis of wave estimation used the data of wind in the year of 2001 until 2010. This data was collected from Juanda Station of BMKG, Surabaya which was placed at 2.8 m from sea water level. This analysis was included wave generation due to wind and the most dominant direction of wind in location of study. Based on historical data, some of wind at location of study was as calm type. Result of field measuring indicated that wind with velocity less than 10 knot had reached 70% of occurrences. Longer data at Juanda Station showed that wind with velocity bigger than 15 knot, 20 knot, and 25 knot sequent were 15 hours, 7 hours, and 4 hours [7]. Blowing time at location of study caused by high wave forming by time was 4 to 6 hours at high velocity. Analysis was used data with wind velocity ≤ 20 knot. It was caused by velocity less than 15 knot would produce unlimited blowing and the possibility to form perfect wave was so small.

Jetty construction of Grati PLTGU was made of concrete sheet pile with length of 12 m and had dimension of 0.40 x 1.0 m at each sheet pile. Existing jetty was made sticking out to the north with length of 500 m. Sheet pile was at the depth of -8.5 m with bed elevation of +0.5 m and over elevation was at +4.0 m (included 0.5 m of pile cap). Jetty construction was strengthened by pile cap so that the construction was not put off from sheet pile and then the pile cap was also strengthened with concrete pile with diameter of 0.6 m and length of 20 m at each interval of 2 m, Existing condition of sheet pile was presented as in Figure 2, 3, and 4 below

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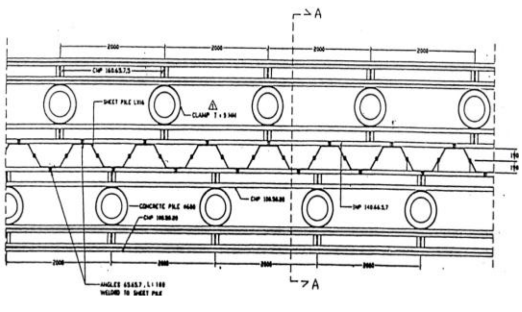

FIG. 2 JETTY CONSTRUCTION OF GRATI PLTGU (LONG SECTION)

At the beginning of design, dredging was planned at elevation of -3.1 m with variation width between 50 to 80m which was used as elevation boundary of dredging capital. It was presented as in Figure 3 and 4 below.

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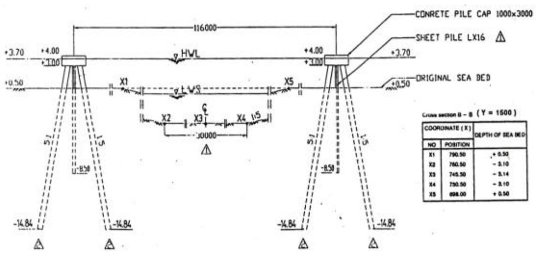

FIG. 3 SECTION OF A-A

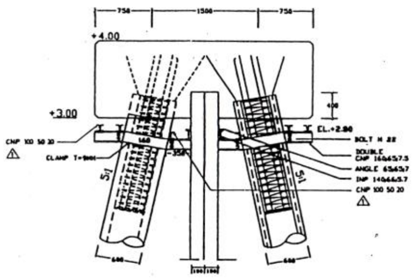

FIG. 4 DETAIL OF CONSTRUCTION

Based on the data of ebb tide, there were three mixed types of ebb-tide and the number of Formizaahi from Surabaya station until Kalianget was in the range of 0.82 until 1.29.

Kind 0f ebb-tide at waterways was dominated by double ebb-tide. Amplitude data of main ebb-tide component at Madura waterways was presented as in Table 1 below.

TABLE I
AMPLITUDE OF MAIN EBB-TIDE COMPONENT AT MADURA WATERWAYS

Constant	Harmonica ebb-tide	Amplitude [A] (meter)	Phase [g]
M2	Principal lunar semi diurnal	0.5652	215.1453
S2	Principal solar semi diurnal	0.3168	212.8703
K2	Lune-solar declination semi	0.0215	37.8770
N2	diurnal	0.1302	0.7139
P1	Longer lunar elliptic semi	0.3961	270.5739
K1	diurnal	0.6996	272.1647
O1	Main solar diurnal	0.2581	187.9189
M4	Soli-lunar declination diurnal	0.0060	229.7010
	Main-lunar diurnal		
MS4	Shallow water over tide of	0.0044	257.1841
	principal lunar		
	Shallow water compound		

Formula of F based on the data as above was F = (0.6996 + 0.2581) / (0.5662 + 0.368) = 1.368. Therefore, trend of ebb-tide type was mixed type and being trend to double daily that was maximum and minimum ebb-tide was twice a day-night but with single range due to first and second ebb-tide had significant difference.

Existing data of PT Indonesia Power was averaged water level elevation of +1.30 m with the highest and lowest elevation was +2.33 m and +0.04 m. This elevation was measured from zero level which was installed at this time and for the next it was used as reference of depth. Design of water level at PLTGU Grati was determined based on analysis and observed data as presented in Table 2 below.

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TABLE II
EVALUATION OF DESIGN WATER LEVEL AT GRATI PLTGU

No	Water level	Symbol	Evaluation (m)
1.	Highest high Water Level	HHWL	+ 3.70
2.	Mean higher Water Level	MHHWL	+ 3.15
3.	Mean Sea Water Level	MSL	+ 1.30
4.	Mean lowest Low Water Level	MLLWL	- 0.55
5.	Lowest Low Water Level	LLWL	- 1.10

Observed data of sediment were included suspension and bed load. Based on the type of composited bed material of waterways, coastal area surrounded location of research was dominated by soft bed material, silt, and clay with sand content of about 10%. Laboratory of Grati PLTGU used 30 samples of average bed material at reclamation area which was distributed at the depth of -1.00 to 4.00 m and size of average bed material sequent for D35, D50, D65, and D80 was 0.029 mm, 0.038 mm, 0.049 mm, and 0.065 mm. Depth of soft land layer reached ± 10 m to ± 1 km from coastal line, and reached ±20 m at ± 1,5 km from coastal line. Figure 5 presented field sample at position of S1 and S30.

Velocity of stream surrounded Wates coast was in the range of 0.10 m/s to 0.33 m/s with dominant direction to east-west and it was about 135^0. The pattern of stream velocity which strongly blew was during 6 hours that was at 12.00 am to 09.00 pm and it was weak at the next hours. It indicated condition of current was influenced by ebb-tide. In the other hand, it was said that dominant direction of current was west and east, and big current had trend moving to the west direction. Waterways at surrounded of water coast was in variety which indicated as turbulent waterways Table 3 described the current velocity at surrounded location of study.

TABLE III
CURRENT VELOCITY AT SURROUNDED LOCATION OF STUDY

Section/ Point	Velocity m/s	Direction of current	Location	
			X	Y
A	0.10	NE	772,430	9,156,055
B	0.15	E	724,014	9,156,228
C	0.15	SE	722,506	9,155,308
D	0.20	W	723,018	9,155,410
E	0.15	W	723,943	9,155,708
G	0,05	SE	923,929	9,155,233

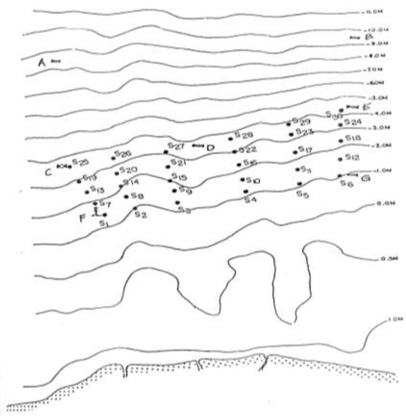

FIG. 5 LOCATION OF SAMPLE

Analysis of effective fetch

Length of effective fetch was analysed for 8 directions of wind and it was measured from observed point with interval of 5^0 and measuring number for each direction was included the measuring at influenced area of fetch ($22,5^o$ in the same direction of time needle and $22,5^o$ in the opposite direction of time needle). Based on the analysis, the effective fetch at Grati PLTGU was with wind direction of north, north-east, south-west, west, and south-east. Table 4 presented shaped fetch at every direction.

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TABLE IV
RECAPITULATION ON ANALYSIS OF EFFECTIVE FETCH

Direction		F_{eff} (km)
North	U	50.207
North-east	TL	92.921
South-west	BL	39.929
West	B	24.082
East	T	108.654

Wave generation by wind

Wave forming at deep water waves was analysed using spectrum formula of JONSWAP. This estimation procedure was for non fully developed sea, either for fetch limited condition or duration limited condition, but for wave there was fully developed sea.

Distribution of wind direction and wave height

Data of wind velocity during 10 years (from 2001 to 2010) was classified into 9 classes with interval of 2 m/s based on the direction of wind. Then it was classified into the percentage of occurrence for every direction during the 10 years. After that, it was drawn as wind rose. Distribution of wind direction was analysed using software of WRPLOT View in the version of 6.5.1 for helping to determine and draw the curve of rose wave at Grati PLTGU. Figure 6 presented wind rose of Grati PLTGU from the year of 2001 to 2010 and Figure 7 presented wave rose of Grati PLTGU from the year of 2001 to 2010

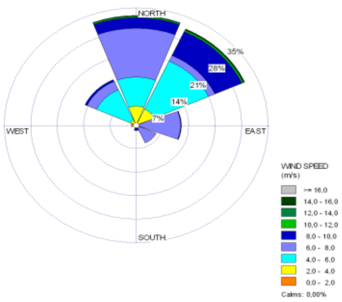

FIG 6 WIND ROSE OF GRATI PLTGU BASED ON DATA OF WIND DURING 10 YEARS (2001 TO 2010)

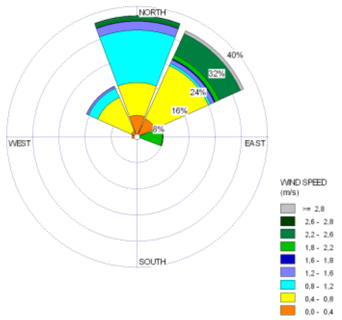

FIG. 7 WAVE ROSE OF GRATI PLTGU BASED ON DATA OF WIND DURING 10 YEARS (1001 TO 2010)

Wave using in modification design

Wave that was used in modification design of existing jetty was necessary to be controlled with design water level height at initial design of jetty which was carried out by PT Indonesia Power at the year of 1996. Existing jetty was designed at elevation of +4.00 m and design water level was determined at the elevation of 3.70 so 0.3 m was as free board of jetty due to maximum sea water level (HHWL). Based on design water level at each return period, significant wave was at return period which was close to +3.70 m. Beside ebb-tide, design of coastal structure had to consider some parameters those were wave set up, wind set up, and the increasing of sea water level caused by global heat. Table 5 presented the analysis of design elevation at every period of wave

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TABLE V
ANALYSIS OF ELEVATION DESIGN AT EVERY RETURN PERIOD OF WAVE

No	Return period	Hs	Ts	Co	Lo	Hb	Global heat	Ebb-tide	Water height, design		Note
									Analysis	existing	
1	2	3	4	5	6	7	8	9	10	g	12
1	2	2.290	6.464	3.232	20.893	1.450	0.300	1.300	3.050	3.7	
2	5	2.931	7.227	3.614	26.118	1.841	0.300	1.300	3.441	3.7	
3	**10**	**3.356**	**7.733**	**3.866**	**29.898**	**2.108**	**0.300**	**1.300**	**3.708**	**3.7**	**OK**
4	25	3.893	8.371	4.186	35.039	2.454	0.300	1.300	4.054	3.7	
5	50	4.291	8.845	4.422	39.117	2.716	0.300	1.300	4.316	3.7	
6	100	4.686	9.315	4.658	43.386	2.982	0.300	1.300	4.582	3.7	

Wave with return period of 10 years, height of 3.356 m, and wave period of 7.733 seconds was as one closely to design elevation (HHWL). The height of wave was used as input of SMS 10.1.8.

Evaluation of sedimentation problem on jetty at Grati PLTGU

Velocity of sedimentation process was influenced by type of material which formed sediment but on the process of sedimentation transport could be caused by media of water and wind. According to Triatmodjo [6], sedimentation process at jetty was influenced by stream and wave. Energy of wave was functioned as generation component of longshore current.

Evaluation due to the direction of coming wave

In the beginning of design, data of wind that was used was in the year of 1981-1982 which the direction of dominant wind based on the data of Meteorology Station at Juanda Airport-Surabaya. This data indicated that dominant direction of wind was from east. The initial design of dominant wind direction was presented as in Figure 8 below. This figure showed that there had occurred the change of dominant wind direction from 2001 to 2010 and it became to come from north-east. But jetty was designed sticking out to north direction which almost upright straight or in the direction of 90^0 due to coming wave. The comparison of the changes of coming wave direction was presented as in Figure 9 below.

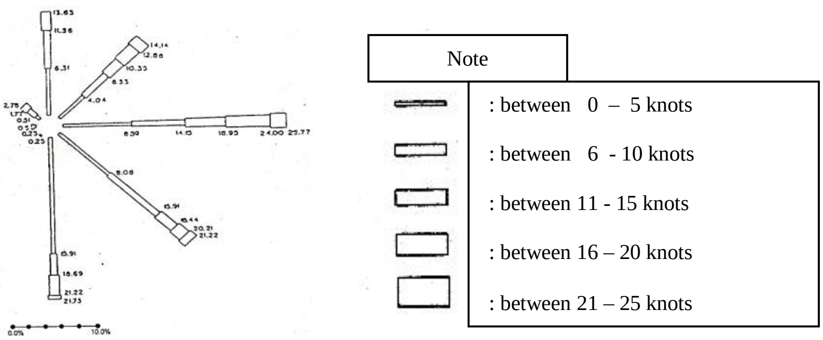

FIG. 8 WIND ROSE IN THE YEAR OF 1981-1992 AT GRATI PLTGU

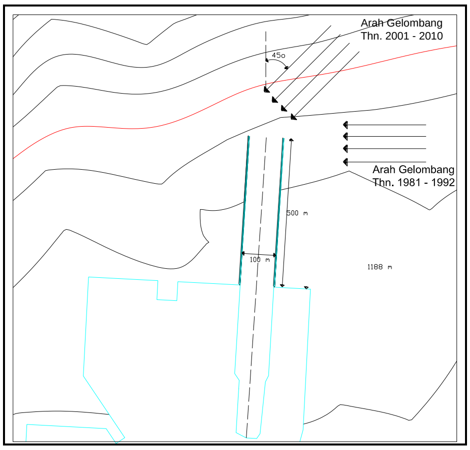

FIG. 9 DIRECTION CHANGE OF COMING WAVE

Evaluation of wave height

Analysis of wave estimation in initial design used data of wind in the year of 1981 to 1992 which was collected from Juanda Station, Surabaya. Analysis on height and wave period was used Sverdrup-Munk-Bret Schneider. Supporting data for this analysis included daily average of wind velocity, maximum wind velocity, duration of wind blowing, length of fetch for local waterways of Grati PLTGU. Result of wave estimation showed that maximum height of yearly wave reached 1.60 until 2.90 m with maximum period of 5.9 seconds to 7.1 seconds. But analysis based on wind data in the year of 2001 to 2010 presented that maximum height of yearly wave was 8.01 seconds until 6.21 seconds.

Evaluation of current pattern at study location

Velocity of current at surrounded of coast was in the range of 0.10 m/s until 0.33 m/s with dominant direction to south-east (approximate to 135^0). Velocity pattern of strong flowing current during 6 hours (12.00 am until 09.00 pm) and it became weak at the next hour and it indicated that current condition was influenced by ebb-tide. Therefore the direction of dominant current was west and east with the big current had a trend moving to west. Beside that, the direction surrounded waterways of Wates coast was in variety and it was indicated that waterways was turbulent. Current pattern which occurred in the year of 2001 to 2010 could be analysed using model of ADCIRC so that it could be seen current vector at the years. Then there was obtained velocity vector as presented in Figure 10, 11, and 12.

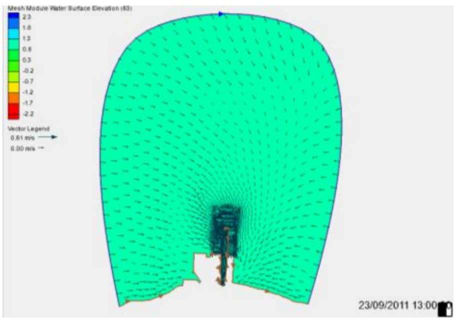

FIG. 10 VELOCITY VECTOR DUE TO EBB-TIDE ON SEPTEMBER 23, 2011 AT 11.00 PM

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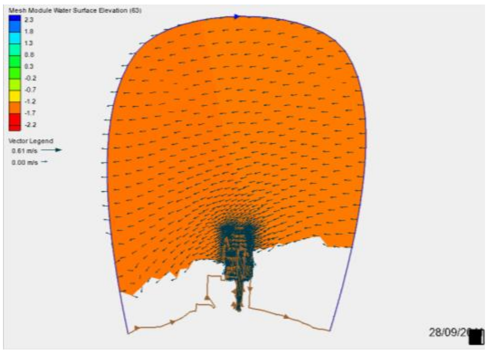

FIG. 11 VELOCITY VECTOR DUE TO EBB-TIDE ON SEPTEMBER 23, 2011 AT 01.00 PM

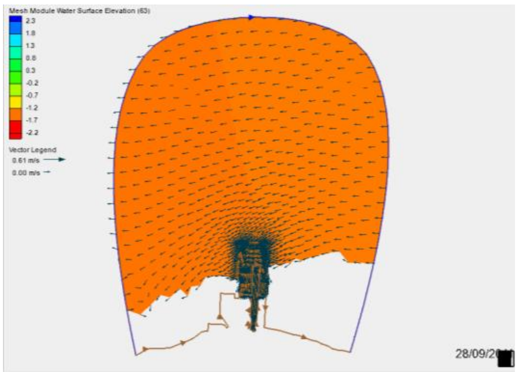

FIG. 12 VELOCITY VECTOR ON SEPTEMBER 28, 2011 AT 01.00 PM

Figure 10 showed the velocity vector on September 23, 2011 at 01.00 pm. Ebb-tide on simulation result of ADCRC was suitable with the condition at location with the highest tide was at elevation of 2.33 m. Figure 10 above presented averaged sea water level of 1.3 m. Figure 11 presented ebb water which was almost the same with historical data that was -1.1 m. Simulation result would produce velocity due to ebb-tide. The biggest velocity was from the direction of east and coming wave was from north-east and it was presented as in Figure 11. The velocity had been calibrated with field condition.

The biggest velocity was from east and the average velocity was 0.35 m/s. But average velocity from north-east when tide was 0.05 m/s. Simulation result showed that the velocity was parallel with coast and then the direction was changed with the angle of 45^0, where the direction had a trend toward the jetty. This problem gave great influence to sedimentation of jetty. But when ebb; velocity had a trend to the direction of west. It caused sediment at jetty could not be transported when ebb condition. From the whole simulation, it was real that the biggest transport sediment was from the direction of east. The velocity at ebb and tide condition was presented as in Figure 13 and 14 below.

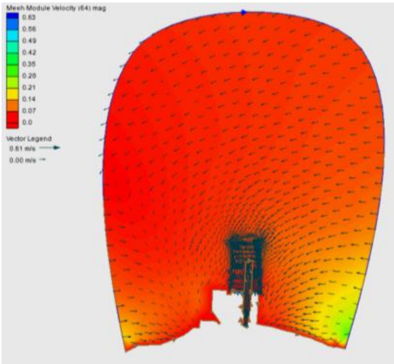

FIG. 13 VELOCITY WHEN TIDE CONDITION

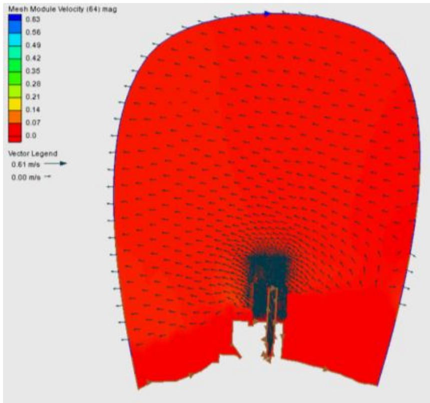

FIG. 14 VELOCITY WHEN EBB CONDITION

Evaluation of jetty effectively due to sedimentation

Bathymetry map of measuring on September 20, 2011 was changed into Digital Elevation Model (DEM) using the software of ArcView 3.3 and the result was presented as in Figure 13. Then map of DEM was changed into grid which was 1 grid had the dimension of 10 x 10 m. The next step was to classify the grid into some slopes which was divided in the interval of 0.153 by different colour. This map was presented as in Figure 15. Number of grid at each interval was calculated by multiplying with grid area of 100 m^2. By numbering the area it would be obtained sea slope in degree as presented in Figure 16. Tangential conversion was needed to change degree unit into decimal. Jetty construction caused the change of sea bed slope at surrounded location of study. Average slope of sea bed was 0.011 before there was jetty construction which was built on 1996. But at the end measuring on September 20, 2011 it was obtained slope of 0.0028. This comparison described that jetty construction caused sedimentation at surrounded of coast.

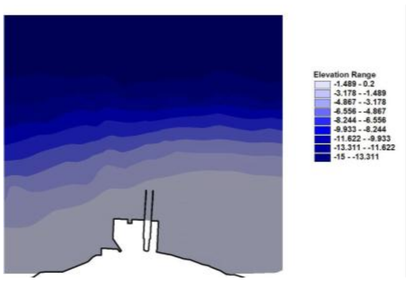

FIG. 15 DIGITAL ELEVATION MODEL ON THE DEPTH OF SEA

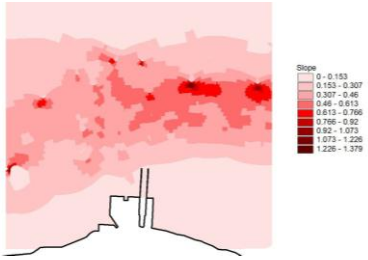

FIG. 16 SLOPE OF SEA DEPTH OF GRID IN DEGREE

Figure 15 presented the change of sediment depth at beginning of design that was at 1996 which the end of jetty was at the elevation of -3.1 m. After 15 years that was on the year of 2011 the elevation became -0.85 m. The difference during 15 years was 2.25 m. Figure 17 presented condition of sediment outside the jetty

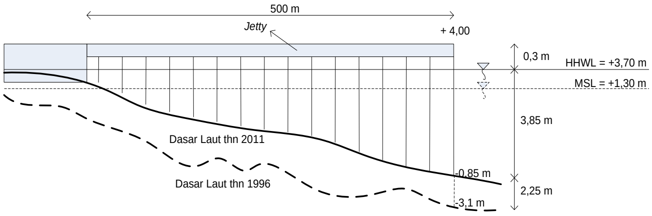

FIG. 17 CONDITION OF SEDIMENT OUTSIDE THE JETTY

Peak elevation of jetty was placed at the elevation of +4.00 m with freeboard of 0.3 m from peak, so that jetty was designed at the elevation of 3.7 m. This elevation was as full sediment condition of jetty, but in the range time of 15 years the bed elevation only reach -0.85 m. Elevation difference for the range time of 15 years from design elevation to the elevation of 2011 was 4.55 m. It described that jetty was designed for more than 30 years due to the area of Grati PLTGU was as reclamation area.

In the long time of the reclamation, it did not give great effect to the sedimentation at water intake channel. The beginning of dredging was carried out by PT Indonesia Power on the year of 2004 because there was problem on sedimentation at water intake channel that sediment had reached at the elevation of +0.4 m which caused boasting due to the elevation of pump was placed at the elevation of -0.04 m. It described that jetty had still not effective in handling sedimentation at water intake channel.

Design of handling on sedimentation

Field observation showed that there was coastal morphology change caused by shallowing at surrounded of jetty construction due to sediment transport from sea.

To solve this problem, it was needed modification of structure which was functioned to decrease shallowing at water intake channel by coastal sediment. Accurate treatment for this case was to lengthen the jetty. [10][11][12][13]

1. To lengthen existing jetty

The base parameter for determining the length of jetty structure was breaking wave zone). Long jetty was placed at the end outside of breaking zone and medium jetty was installed between LLWL and breaker line. Therefore it was necessary to find long jetty until breaker line and it was carried out by overlay simulation result STWAVE with bathymetry map so that could be obtained jetty length until to breaker line.

2. Analysis of refraction and breaking of wave

This analysis used the software of SMS which was carried out with model of STWAVE. The result was graphically analysis refraction and breaking of wave. Figure 16 presented the visual Cartesian grid for bathymetry data and Figure 19 presented breaker zone on analysis result of STWAVE

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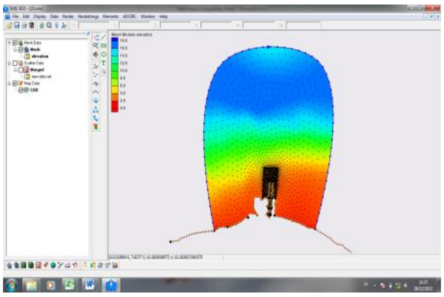

FIG. 18 VISUAL CARTESIAN GRID BATHYMETRI DATA

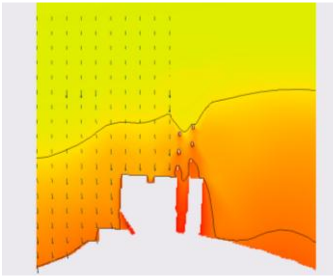

FIG. 19 BREAKER ZONE ON ANALYSIS RESULT OF STWAVE

3. Design of modification

Design of modification was planned based on breaking wave that was produced from analysis of STWAVE as presented in Figure 19. This figure was overlayed with bathymetry map so that the boundary of breaking wave could be found. This modification was as follow: a) Location of jetty construction was planned as 25 m before breaking wave; b) Based on coming wave, jetty construction was designed straight upright or by angle of 45^0 due to the direction of north-east; 3) Jetty at right side was lengthen until 178 m with radius of 150 m where jetty at left side followed the projection of jetty length in the right by the angle of 45^0; and 4) length of jetty construction from intake water pump until at the end was 1,188 m where the length was increased 188 m from existing condition. Figure 20 presented design on first modification of jetty.

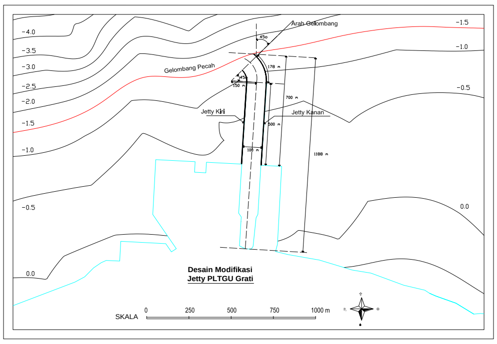

FIG. 20 DESIGN ON FIRST MODIFICATION OF JETTY

4. Addition of 20 m at breaking wave J

Jetty construction was usually built until the outside boundary of breaker zone that was when ebb water level (LLWL). But jetty design at study location was impossible because elevation of LLWL was too close.

Based on the design criteria which was published by Unit of Research and Development Public Work Department, ending of jetty was better if it was placed at the distance of 20 m from breaking wave. Therefore design as in Figure 20 was lengthened until 45 m as presented in Figure 21.

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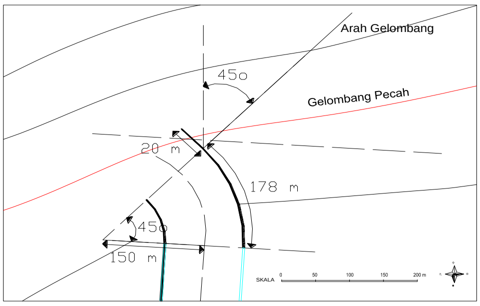

FIG. 21 ADDING OF 20 M ON BREAKING WAVE

5. Dredging at water intake channel

The other alternative was by dredging. Dredging was carried out when design modification of jetty had not been still effective in minimizing sedimentation at water intake channel. Beside that, dredging was become as the end alternative when construction cost was not proportional than dredging cost every year.

Dredging at water intake channel had to attend some aspects as follow:

a. Dredged groove

Dredged groove was as groove with radius of dredging had the width as well as dredged ship. Radius of swing dredged ship of dam or lake was 30 m as presented in Figure 22 where was placed at the as of water intake channel.

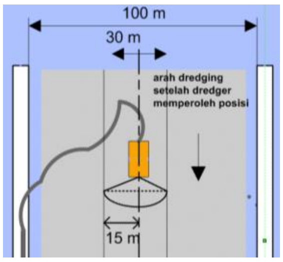

FIG. 22 SWING DREDGED SHIP OF DAM OR LAKE

b. Sedimentation at water intake channel

The volume of sedimentation could be calculated using 2 manners as follow:

- -Average of sediment per-year was 32,851 m^3. Therefore, if number area of dredging was 30 x 1000 m = 30.000 m^2, then volume of dredging was V= (30,000 x 32,851 / 78,000) = 12,635 m^3
- -Volume of sediment could be estimated as 0.432 m^3/ year/m^2. Therefore, if number area of dredging was 30,000 m, then volume of dredging was V = 0,432 x 30.000 = 12.971 m^3 ~ 13.000 m^3

The average of dredging which was carried out by PT Indonesia Power when the elevation was < 0.4 m and elevation at the end of jetty was -0.85 m.

c. Minimum elevation which was dredged

Elevation which was used in this study was pump elevation from PT Indonesia Power because based on historical data, sedimentation was occur at water intake channel, where sediment had reached the elevation of +0.4 m and it caused boasting due to the elevation of pump was placed at the elevation of -0.04 m.

d. Area of reclamation

Area reclamation at study location had determined by PT Indonesia Power where the area was as free area and the elevation had still not the same as construction of road access. Figure 23 presented the reclamation area of PT Indonesia Power

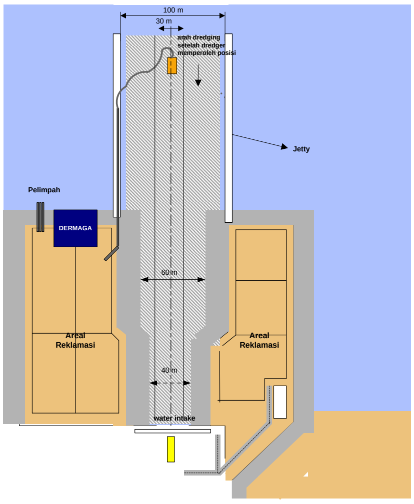

FIG. 23 RECLAMATION AREA OF PT INDONESIA POWER

e. Dredged volume in one year

Based on point a to d, there was needed the maintenance dredging eery year at the elevation of -1.1 m with groove width was 30 m along the distance of 100 0 m. Therefore, volume of sediment which had to be dredged V =(1.5 + 0.25) x 0.5 x 1.000) x 30 = 26,250 m^3

f. Analysis of sedimentation after modification of jetty

After modification of jetty, sedimentation was analised using the extention of SMS software that was PTM (Particle Tracking Model) [14] and it was as the end step of sediment dredging at water intake channel on existing condition of Grati PLTGU. The aim of PTM analysis was to obtain sediment dredging which was caused by cureent and wave at study location. This study was comparing 3 jetty models as follow:

- *Existing jetty*

  Dredged volume in one month was 2,439.628 m^3, so that was obtained velume in one year was 29,275,535 m^3. But real volume at water intake channel in one year was 32,85,,268 m^3. The difference between model and field condition was 3,576,733 m^3 with relative error of 10.187%.

- *First modification of jetty (it was lengtherned until 25 m before the breaking wave)*

  Volume in one month was 2,268,779 m^3, so that the volume in one year was 27,225,346 m^3. Volume at water intake channel in one year for existing jetty was 29.275,535 m^3. The difference between model and field condition was 2,050,189 m^3. Based on the difference of volume, it was concluded that effectivity on first modification of jetty in reducing sediment at water intake channel was 7.003 %.

- *Second modification of jetty (it was lengtherned until 2o m before the breaking wave)*

  Volume in one month was 2,259,893 m^3, so that the volume in one year was 27,118,717 m^3. Volume at water intake channel in one year for existing jetty was 29.275,535 m^3. The difference between model and field condition was 2,050,189 m^3. Based on the difference of volume, it was concluded that effectivity on first modification of jetty in reducing sediment at water intake channel was 7.367$

IV. CONCLUSION

Based on the analysis as above, it was concluded as follow:

1. Sedimentation at water intake channel with existing jetty design according to simulation result of PTM was 29,275,535 m^3.
2. Based on the direction of coming wave there were 2 designs of jetty construction as follow:
   a. The first modification of jetty was being designed straight upright or by angle of 45^0 due to the direction of north-east. Jetty on the right side was lengthening until 178 m with radius of 150 m which jetty in the left side followed the projection of jetty length on the right side due to the angle of 45^0.
   b. The second modification of jetty was being designed with jetty length followed as first one then right side of jetty was placed on the direction of 20 m from breaking wave

3. Volume at water intake channel for existing jetty in one year was 29,275.535 m^3. The difference between first modification and existing of jetty was 2,050.189 m^3 with affectivity of first modification of jetty was 7.003%. But the difference between first modification and existing of jetty was 2,156.818 m^3 with the affectivity of 7.367%.
4. Accurate maintenance dredging which was carried out at existing jetty was to make groove along water intake channel with the width of 30 m and it held the elevation of -1.1 m every year. Therefore it was obtained minimum volume for dredging was 29,000 m^3 because volume which was produced by first and second modification was more than 29,000 m^3 and elevation of maintenance dredging was -1.1 m without being wide or shallow the groove of dredging.

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