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Comparative Study between Groin and T-Head Groin

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Abstract*— *This study conducted a comparative study between groin and T-groin. The study was done by developing stable coastline equation between groins and between T-Head groins. Stable coastline equation is the follow up of previous research by the same researcher. Meanwhile, stable equilibrium coastline equation between T-Head groins is the development of stable coastline between groins equations.

Comparation study in erosion on the downstream groin and the maximum erosion shows that T-groin provides better coastal protection than groin.
Keywords*— *stable coastline, groin, T-Head groin.

I. INTRODUCTION

Van Rijn [1] has acquired that as a result of differences in wave height as a result of a diffraction, there is littoral current toward shadow zone and down drift groin at the coastline protected by groin (Fig.1). The littoral current carries littoral drift that is deposited at the down drift groin that can cause sedimentation at down drift groin; therefore the presence of this littoral drift acts as protector of down drift groin against erosion, at least reducing erosion. Vadya[2], show that impact of groin length is less erosion on downdrift groin as the length of groin increases.

The longer the groin the greater the shadow zone, the larger the difference of water surface elevation and the greater the littoral drift, the greater the sedimentation at the downstream groin. In addition to extending the groin, the widening of the shadow zone can be done by constructing T-head at the groin. Groin with this T-head is called T-head Groin or T-Groin (Fig.2). With the presence of this phenomenon, it is estimated that T-Groin will provide better coastal protection than using groin.

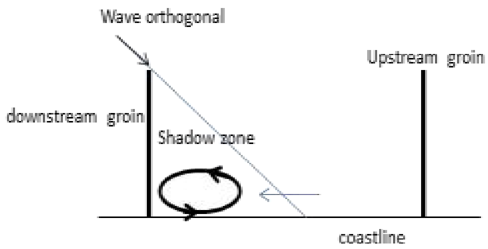

Fig.1: Coastal hydrodinamic at the coast between two groins

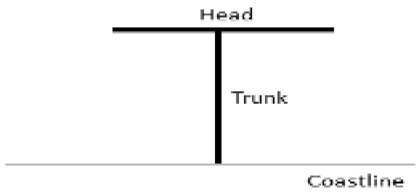

Fig.2: T-Head Groin or T-Groin

Even though there are not so many researches on T-groin, the result of the research shows that there is sedimentation at the downstream groin (Fig.3). The researches was done by among others, Bodge [3], Ozolcer [4], Elko [5], Ozolcer [6] Hanson [7] Frech, F.F [8], Ishihara [4] and Sato [9]. Those results of the researches strengthens the assumption that T-groin will provide a better coast protection than groin.

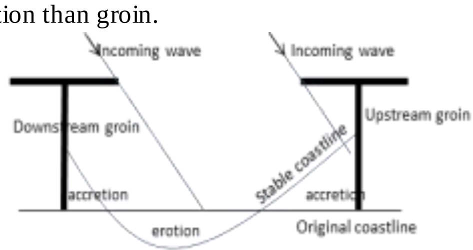

Fig.3: Erotion and accretion between T-groins

Hutahaean [10] has developed a method to build stable coastline equation between groins. In this research, the method is applied at T-groin to obtain stable coastline equation between T-groins. Then, a comparison is done to the phenomenon of erosion and sedimentation that occur at the formation of stable coastline between the two types of groin.

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II. STABLE COASTLINE EQUATION BETWEEN GROINS (REVIEW OF PREVIOUS STUDY)

Stable coastline between T-groins equation will be formulated the same way as the formulation of stable coastline between groins equation (Hutahaean [10]). Therefore, the next section will discuss first the formulation of stable coastline between groins equation.

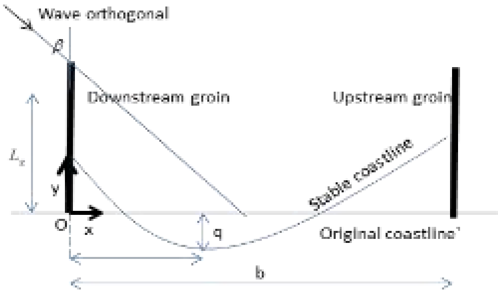

Fig.4: A Sketch of stable coastline between groins

Stable coastline between groins equation is approximated using quadratic polynomial equation, i.e.:

$$y(x) = c_0 + c_1 x + c_2 x^2$$

where c_0 , c_1 and c_2 are determined using conservation law of mass and stable coastline characteristics as on Fig.4, i.e.:

1. Conservation Law of Mass:
   Conservation Law of Mass in this case is the volume of erosion is similar to the volume of accretion

   By ignoring sand porosity, the conservation law of mass can be stated as:

$$\int_0^b y(x)dx = 0$$

   By completing integration and dividing the integration with groin gap width b, the first equation is obtained, i.e.:

$$c_0 + \frac{c_1}{2}b + \frac{c_2}{3}b^2 = 0 \qquad \text{..........(1)}$$

2. Boundary condition at the upstream groin
   At the upstream groin, where $x = b$ the boundary condition is done $\frac{dy}{dx} = \tan\beta$,

$$c_1 + 2c_2 b = \tan\beta \qquad \text{........(2)}$$

3. At the minimum point, i.e. at $x = r$, $\frac{dy}{dx} = 0$ and $y = -q$

   a. $\frac{dy}{dx} = 0$

$$c_1 + 2c_2 r = 0$$

$$r = -\frac{c_1}{2c_2}$$

   b. $y = -q$

$$-q = c_0 + c_1 r + c_2 r^2$$

   Substitute $r = -\frac{c_1}{2c_2}$

$$c_0 + c_1\left(-\frac{c_1}{2c_2}\right) + c_2\left(-\frac{c_1}{2c_2}\right)^2 = -q$$

$$c_0 c_2 - \frac{c_1^2}{4} + q c_2 = 0 \qquad \text{......(3)}$$

4. Approximation for r , $r = (\alpha L_g - q)\tan\beta$
   This approximation is a hypothesis, as an effort to incorporate the role of the length of groin L_g where α is a coefficient with a set value, i.e. $\alpha > 1.0$ for increasing the influence of L_g , whereas $\alpha < 1.0$ for decreasing the influence of L_g . This value of α can be obtained by conducting a calibration to the test result of physical model in the laboratory. In this research $\alpha = 1$ is used.

$$-\frac{c_1}{2c_2} = (\alpha L_g - q)\tan\beta$$

$$(\alpha L_g - q)\tan\beta + \frac{c_1}{2} = 0 \qquad \text{........(4)}$$

The four equations, i.e. equations (1), (2), (3) and (4) can be completed using Newton-Rhapson iteration method for non-linear equations system with c_0 , c_1 , c_2 and q as the unknown. The initial value for the iteration is $c_0 = -p$, where p is determined randomly with a value around -1.0 or +1.0, $c_1 = -\tan\beta$, $c_2 = \frac{3\tan\beta}{2b}$.

Whereas, the estimation of initial value of q , the following equations are used,

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$$r = -\frac{c_1}{2c_2}$$ and

$$-q = c_0 + c_1\left(-\frac{c_1}{2c_2}\right) + c_2\left(-\frac{c_1}{2c_2}\right)^2$$

Example of equation result

The equation is done at groins gap $b = 100$m, length of groin $L_g = 30$ m with the angle of the incoming wave β: 10^0, 20^0 and 30^0. Influence Coefficient L_g, i.e. α = 1.

Table.1: Polynomial Coefficient of Equation Result

β^0	c_0	c_1	c_2
10	-2.641	-0.009	0.001
20	-4.853	-0.036	0.002
30	--6.718	-0.087	0.003

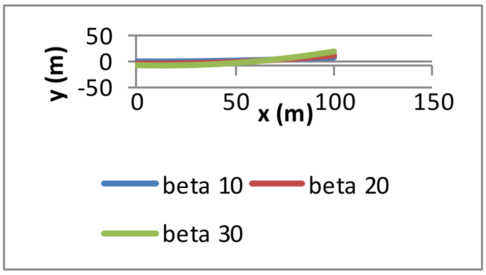

Fig.5: Stable coastline between groins, equation result

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(Figi 6) presented stable coastline graphs for varied groin length of L_g, i.e. 30 m, 50 m, and 70 m, with groins spacing 100 m and incoming wave angle 30^0. The result of the equation shows that the longer the length of the groin, the smaller the erosion groin will be, where for groin with a length of 70 m, there is an accretion at the downstream groin. This represents the presence of longshore current effect toward downstream groin as the result of the study Van Rijn [1] and agrree with Vadya's study [2].

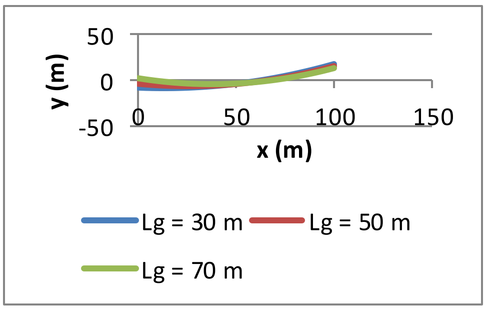

Fig.6: Stable coastline with varied length of groin L_g

III. STABLE COASTLINE BETWEEN TWO T-GROINS EQUATION

Equation for stable coastline between T-groins is formulated using the same method with the previous part, by incorporating the role of arm T where the length of half of the arm is t (Fig.7), as follows:

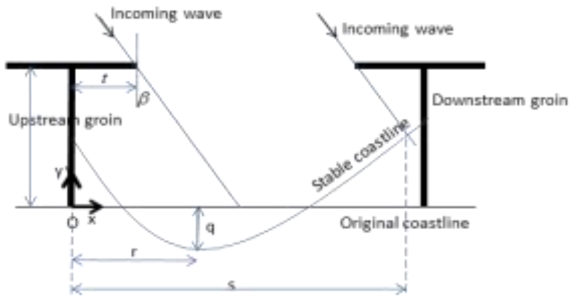

Fig.7: Sketch of stable coastline between two T-Groin

a. Boundary condition of $\frac{dy}{dx} = \tan\beta$ is done at the point with abscissa $x = s$, therefore (2) becomes,

$$c_1 + 2c_2 s = \tan\beta \qquad ....(5)$$

b. Equation for s

$$(c_0 - a_0) + (c_1 - a_1)s + c_2 s^2 = 0 \qquad ....(6)$$

This is an equation of point intersection between non diffracted wave originated at the left arm of upstream groin with stable coastline (Fig 7), where the wave ray equation is:

$y(x) = a_0 + a_1 x$, where $a_1 = \tan\theta$, $\theta = -(90 - \beta)$ and $a_0 = L_g - a_1(b - t)$.

c. Incorporating the role of arm T downstream at r.

$$r = (\alpha L_g - q)\tan\beta + \alpha t$$

Therefore (4) becomes,

$$(\alpha L_g - q)\tan\beta + \alpha t + \frac{c_1}{2} = 0 \qquad ....(7)$$

Similar to the equation for groin, α at equation (7) is a coefficient that is obtained through calibration with the result of physical model, where in this research α = 1 is used.

Using equations (1), (5), (3), (7) and (6), unknowns c_0, c_1, c_2, q and s are calculated using Newton-Rhapson's iteration method.

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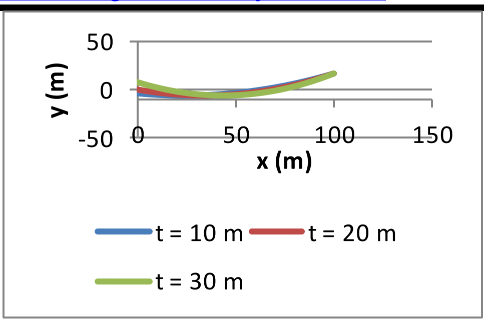

Fig.8: Stable coastline between T-groins, varied t

(Fig. 8) presented equation result for incoming wave angle $\beta = 15^0$, L_g (Trunk) = 30 m, groins gap (distance between trunk) $b = 100$ m, whereas the length of half head t varies, 10, 20, and 30 m. The figure shows that the longer the half head t, the smaller the erosion at the downstream oin will be, and when the half head long enough, the downstream groin accreted. Therefore, head also protect the coast around downstream groin against erosion, and protect against outflanked (Fig.9).

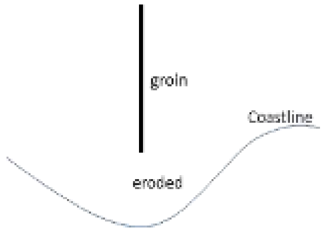

Fig.9: Outflank groin

IV. COMPARISON BETWEEN GROIN AND T-GROIN

Table (1) show erosion at the downstream (Erd) and maximum erosion (Ermax) at groin and T-groin. Angle of incoming wave $\beta = 15^0$, groin gap width (trunk to trunk) 100 m. The length of groin L_g varies from 40 m up to 80 m. The length of trunk (L_g) at T-groin is 30m with the length of half T-head varies, i.e. t = 10 m up to 50m. By considering T-groin as L-groin, the same total length between groin and L-groin, i.e. for groin length of L_g, 40 m, can be compared with L-groin with the length of trunk 30 m + 10 m half T-head , etc.

Table (1) shows that for the same length of structure, Erd and Ermax at T-groin are always smaller than Erd and Ermax groin. And the additional length of head at T-groin is more effective than the additional length of groin in reducing Erd and Ermax.

Table.1: Comparison between groin and T-groin

Groin		
L_g (m)	Erd (m)	Ermax (m)
40	-8,14	-8,19
50	-7,87	-7,96
60	-7,59	-7,73
70	-7,3	-7,5
80	-7	-7,29
T-Groin $L-trunk$=30 m		
t (m)	Erd (m)	Emax (m)
10	-7,64	-7,84
20	-6,47	-7,02
30	-5,15	-6,27
40	-3,65	-5,62
50	-1,94	-5,07

V. CONCLUSION

The method that is developed is quite simple to be applied and can reproduce the features of stable coastline between groins or between T-groins, and erosion and sedimentation that occur. However, a calibration is still needed to the physical model.

Even though the equation that is produced still requires physical model test, but considering the same method is used, it can still be concluded that coastal protection using T-groin is more effective than using groin.

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