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The Sedimentation Patterns on Groyne Field Due to Different Placement on the River Bend

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ABSTRACT

To keep stability river environment from damage due to river bank erosion, can be done by to planed a groyne. Groyne functions is to be change the current flow being low, due to the current flow is low will be occur sedimentation on groyne field. One indicator of good placement and good size of groyne was yield the most accumulated of sedimentation on groyne field. Previous research states that are the longer size of groyne will result in more accumulation of sediment, but on the certain conditions the patterned sedimentation is not good, so that's how to get a good groyne placement witch be yielded the most accumulated and good patterned of sedimentation occurred. To solved this research had be done modelling groyne placement that be done simulation to many case of groyne placement using mathematical modeling approach by finite different method. The simulation results shown the different sedimentation pattern on the groyne field off each case groyne layout. In the case of certain layout has resulted the good sedimentation pattern but in the case of the other position and size of groyne has resulted the occurrence of local scouring behind the groyne.

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INTRODUCTION

At a certain river environment, to protection of the riverbank with controlling the current flow is a good alternative, that's to build a groyne with a good placement was expected to affect existing flow current into the expected flow pattern. Building groyne with a good placement will be able to control the current flow around groyne it so there will be capture of sediment on around the groyne field. Previous research states that are the longer size of groyne will result in more accumulation of sediment, but on the certain conditions the patterned sedimentation is not good, so that's how to get a good groyne placement witch be yielded the most accumulated and good patterned of sedimentation occurred. To get a good groyne placement need a study of its own, that is by physical models or mathematical models.

Study was done to many cases of groyne placement with a combination of influencing parameters and to save the time and effort will be carried out by method of numerical simulations. Good placement will cause of much sedimentation accumulation on around the groyne field and finely sedimentation pattern. To be able to make the effort a good groyne placement at the river, it is necessary to study on some cases of the groynes layout on the curve channel.

Research carried out on several case layout with a combination of 3 alternative positions and 3 size at every position of groyne. In each study of each case will be simulated on same flow velocities and same sediment concentration on same geometry of the curve channel.

1. The research has been done with regards to the groyne placement:

On issues concern on groyne placement, has been studied by Suharjoko (1999, 2001), and Jungseok, 2005 to get determination of the good distance between the groyne. Heereveld (2006), conducted a study on the submersible groyne aimed to reducing the speed of the water flow at the bottom and increase in the upper stream (fairway). Brandimarte *et al*, (2006) and Prohaska (2006), study of groyne functions as erosion control, while Zhang (2007), study on flow problems and the changes process on the river bad around the groyne, Armani (2010), to analyze the problem of scouring and depositions in around a groyne system. Kuhnle *et al*, 1999,

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conducted experiments on groyne immersed (submerged spur dikes), and Zhang, Mizutani and Nakagawa (2011), investigating the influence of groyne size against of the sedimentation on bed topography around groyne.

The studies mentioned above have been applied to simulate the flow pattern and to get an idea of the distribution of sediment concentration and the concentration of the vortex flow around the groyne. So in this study are expected to gain knowledge about to get a good groyne placement will be yielded the most accumulated and good patterned of sedimentation occurred.

II. Methodology:

Research conducted on some cases the of groyne placement that's combinations from 3 alternative positions of groyne and 3 size of groyne at every position. In study of each case submitted will be simulated by giving the same flow velocities and the same concentration of sediment to the same geometry of curve channel. The alternative of groyne positions planned on three variations that is; Position-1, if a groyne built on the initial of the arc bends, Position-2, if a groyne built on the 1/4 upstream of arc bends and Position-3 is position the groyne built on the middle of the arc bends, more details can be seen in **Figure 1** below. While the size of the groyne on each position is size-1 is $L = 1/5 B$, size-2, is $L = 1/3 B$ and size-3 is $L = 1/2 B$, where B = width of the river and L = the length of groyne.

Simulation of every cases using Numerical models 2-Dimensional Horizontal Flow that's constructed of continuity and momentum flow equations and sediment transport equations (Suharjoko 2012).

In each case study has been simulated to be given the boundaries of the flow water at the same speed and the same sediment concentration and then evaluated the results of the sedimentation pattern be occurred.

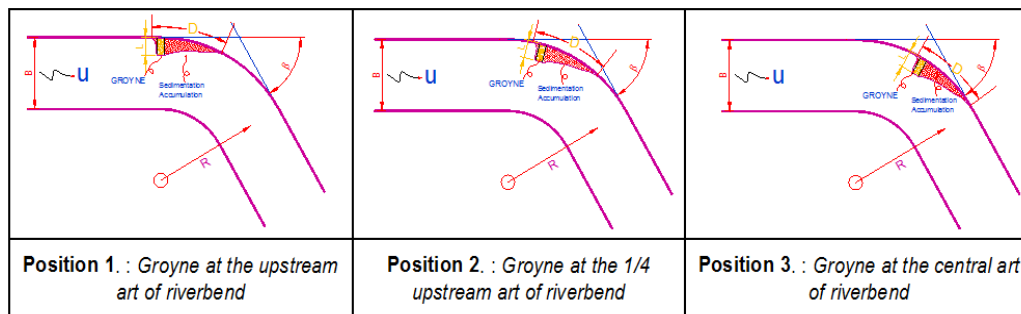


Fig. 1: Three various of groyne position placement on the river bend.

III. Discussion:

1. Development Numerical Models:

Numerical models of water flow and sediment transport constructed in this study is the numerical model 2-D of flow water and sediment transport. This model is composed of 2-D flow equation from the Navier-Stokes and the transport sediment equations together with the Bad deformations equation. In summary the equation is as follows.

2. Numerical Model Equation:

a. The 2-D flow equation:

Flow motion equations can be derived from completion of the mass conservation equations and momentum equations of water motion. Momentum equations derived from Newton's Second Law. The mass conservation equations and momentum conservation of water motion are as follows;

$$\frac{\partial \eta}{\partial t} + u \frac{\partial u}{\partial x} + v \frac{\partial u}{\partial y} = 0$$

$$\frac{\partial v}{\partial t} + u \frac{\partial v}{\partial x} + v \frac{\partial v}{\partial y} = -g \frac{\partial \eta}{\partial y} + \frac{g}{C_z^2} v \sqrt{u^2 + v^2} + \nu \nabla^2 v$$

$$\frac{\partial v}{\partial t} + u \frac{\partial v}{\partial x} + v \frac{\partial v}{\partial y} = -g \frac{\partial \eta}{\partial y} + \frac{g}{C_z^2} v \sqrt{u^2 + v^2} + \nu \nabla^2 v$$

Value of Chezy coefficient (C_z) can be calculated by equations bellow :

$$C_z = 18 \log \frac{12h}{k + 2\delta/7}; \nabla^2 = \left(\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} \right), \delta = \frac{11.6\nu}{u^*},$$

$$u^* = \sqrt{ghI} \text{ and } I = \frac{d\eta}{dx}.$$

b. The transport sediment equations:

The transport suspension sediment equations [Wang, 2004],

$$\frac{\partial(hC_k)}{\partial t} + \frac{\partial(UhC_k)}{\partial x} + \frac{\partial(VhC_k)}{\partial y} = \frac{\partial}{\partial x} \left(\varepsilon h \frac{\partial C_k}{\partial x} \right) + \frac{\partial}{\partial x} \left(\varepsilon h \frac{\partial C_k}{\partial y} \right) + \alpha \omega (C_{*k} - C_k) \quad (5.4)$$

C_k = konsentrasi suspended load sediment, C_* suspended load transport capacity, ε is turbulen diffusi sediment coefficient, k is number of grain sediment class, $\varepsilon = \nu_t / \sigma_c$, σ_c is Turbulent Prandl-Schmidt number between 0,5 - 1,0, α is non-equilibrium adaptation koefisien, ω fall velocities sediment particle, S_x and S_y is the disperse factor. The disperse factor on the river straight or simple geometry is usually omitted.

c. Bad Deformation equations:

Singh, 2005, the bad elevation changes due to sediment erosion and deposition of sediment can be represented as the following equation: $(1 - p'_m) \left(\frac{\partial z_b}{\partial t} \right) = \alpha \omega_s (C - C_*) + (q_b - q_{b*}) / L_s$ C_* dan q_{b*} are provisions

that must be known in advance and can be approximate $C_* = p_b C^*$, $q_{b*} = p_b q_b^*$, p_b is the bed material gradation, C^* is the potential transport of suspended-load capacity, the potential q_b^* is the potential transport of bed-load capacity.

$$(1 - p) \frac{\partial z_b}{\partial t} + \frac{\partial(q_{bx} - q_{sx})}{\partial x} + \frac{\partial(q_{by} - q_{sy})}{\partial y} = 0$$

Dyer 1986 on Widagdo 1998, introduced the basic equation changes due to sediment deposition as follows;

$$\frac{dm}{dt} = p w_s \left(1 - \frac{\tau}{\tau_c} \right)$$

where m is the mass of the sediment settle, p is the sediment porosity, and τ_c , τ is the base shears and base critical shears that cause sediment settling.

$$\tau = \gamma R S$$

R is hydraulic radius.

3. Writing programs:

Programs written in Visual BASIC, program organization consists of the following parts:

- Input data
- Process Simulations,
- Output.

Outline the program flow chart that explains the parts of the process can be seen in **Figure 2** below.

4. Simulation and results:

The simulation results of several case layout with a combination of 3 alternative positions and 3 groyne size of each position, given the same speed $u = 1.2$ m/s and the same sediment concentration is 75 mg/m³. Simulation results show flow patterns and sedimentation patterns around the groyne, sample results can be seen in Figure 3, 4 and 5 below and analyzing the sedimentation patterns result of any case will be shown on Table 1 explained as follows;

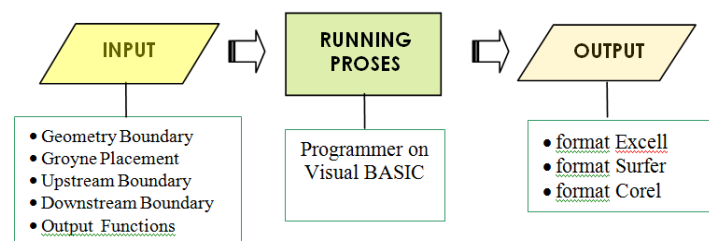


Fig. 2: Flowchart Programming on Groyne Placement Simulations.

a. At position-1, position groyne at the beginning of the arc bends and if the length groyne (L) is equivalent to $1/5$ of the river width (B), the simulation results show good sedimentation, but if the length of groyne be longer that is $L=1/3B$ up to $L=1/2B$, simulation results indicate the occurrence of vortex flow with higher speeds, so that the result of this vortex flow causes scours near the groyne, so that the resulting sedimentation pattern is not good.

b. At position-2, position at the $\frac{1}{4}$ upstream of the arc river bends, results that the sedimentation pattern around the groyne is more ugly than in the case of position-1, on the case that's groyne length equal to $\frac{1}{5} B$ the sedimentation pattern has presence of scours around the end point of the groyne and if groyne length up to $\frac{1}{5} B$, the sedimentations pattern had most scouring.

c. In the position-3 is position the groyne built on the middle of the arc bends. From the simulation results in the case of groyne length (L) equal to $\frac{1}{5} B$ resulted in sedimentation patterns around the groyne is good, so if the groyne length equal to $\frac{1}{3} B$, but if the groyne length equal to $\frac{1}{2} B$ sedimentation pattern has begun to show presence of scours around on the end point of the groyne.

From the above description that a good groyne's length is smaller than $\frac{1}{5} B$, while its position is at Position-1 and Position-3.

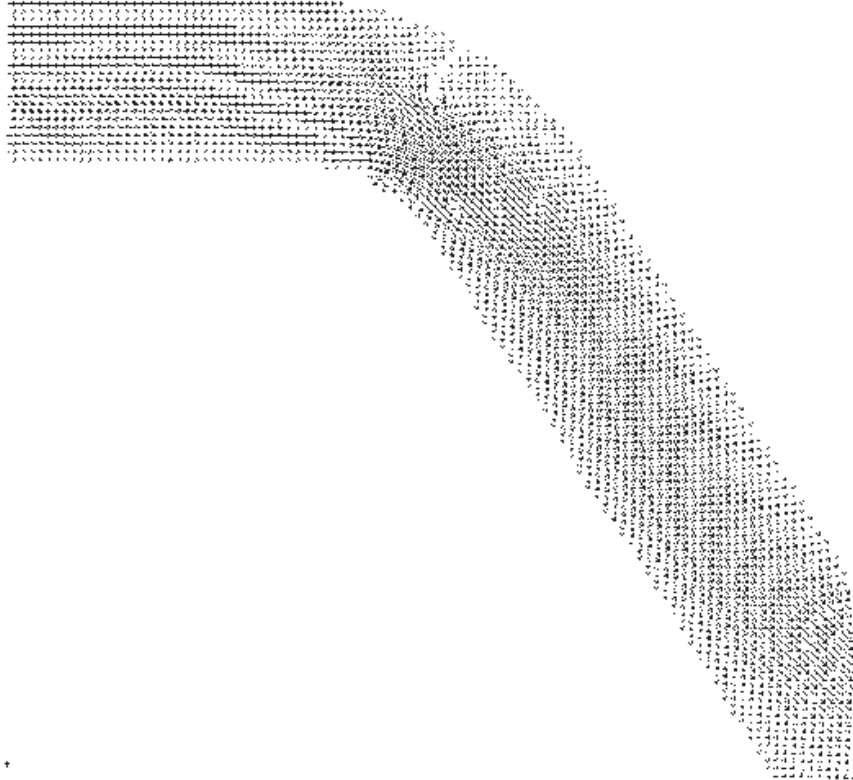


Fig. 3: Vektor Flow Velocities on Groyne field of the Groyne Position-3, Groyne length $L = \frac{1}{3} B$.

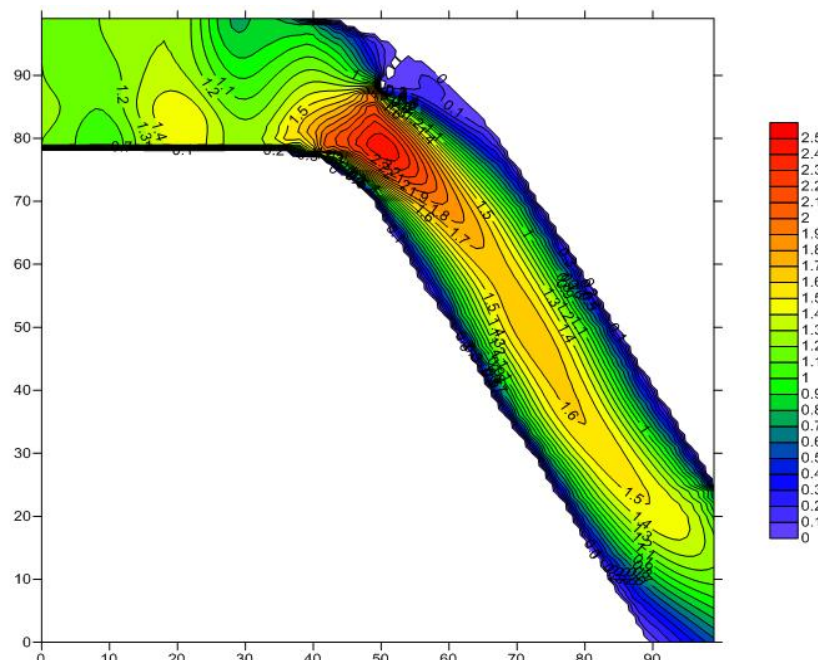


Fig. 4: Flow Velocities Distribution on Groyne field of the Groyne Position-3, Groyne length $L = \frac{1}{3} B$.

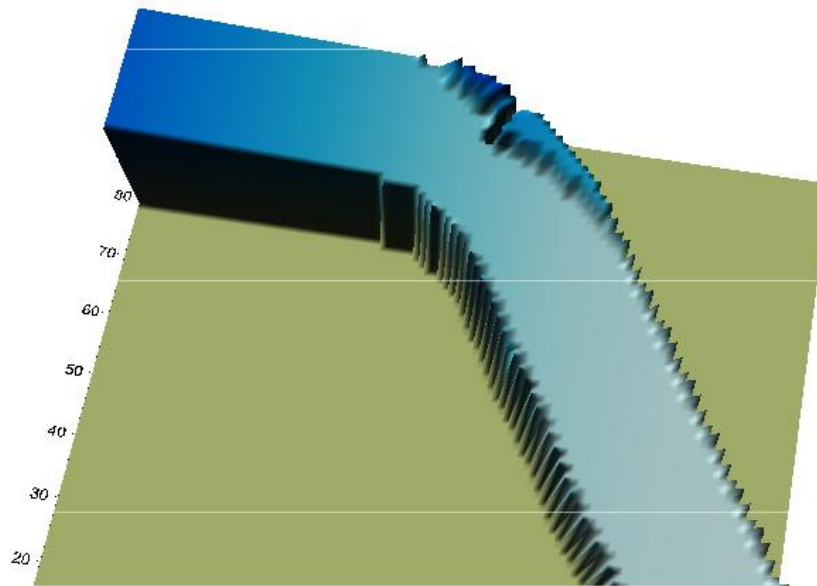


Fig. 5: Sedimentation on Groyne field of the Groyne Position-3, Groyne length $L=1/3 B$.

Table 1: Figure of sedimentations patterned on groyne field, simulation result of any case Groyne Placement Placement.

	Groyne Length $L = 1/5 B$	Groyne Length $L = 1/3 B$	Groyne Length $L = 1/2 B$
Position-1, groyne on the initial of the arc bends			
Position-2, groyne on the 1/4 upstream of arc bends			
Position-3, groyne on the middle of the arc bends			

IV. Conclusion:

Studies on Sedimentation Patterns around the groyne based on a different positions was simulated to several case layout plant of groyne with combinations of 3 alternative positions and 3 size at every position of groyne. Alternative groyne positions planned on three (3) variations that is Position-1 groyne with a groyne on the initial of the arc bends, Position-2 is position the groyne on the $1/4$ upstream of arc bends and Position-3 is position the

groyne in the middle of the arc bends. While the size of the groyne on each position is 1) $L = 1/5 B$, 2) $L = 1/3 B$ and $L = 1/2 B$, where B = width of the river and L = the length of groyne.

The simulation results of several case layout with be combination of 3 alternative positions and 3 groyne size of each position, with given the same speed that's $u = 1.2$ m/s and the same sediment concentration is 75 mg/m³ on the river bend had radius bend equal 30 m. Simulation results show flow patterns and sedimentation patterns around the groyne field.

The analysis shown that the length of groyne as good as possible smaller than $1/5 B$, whereas the position is a good position-1 and position-3.

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To enrich understanding good placement of groyne on the river bend, need more research to increase variety of angles and radius bend of river studies.

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