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# A Scouring Patterns Around Pillars of Sekanak River Bridge

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**Abstract.** Musi River is the main river with a river length of more than 750 km and the average width of 540 m is still affected by the tides of seawater from the thirteen existing river basin systems and one of the rivers in question is the Sekanak river where changes in the river sekanak this occurs as a result of factors nature and human factors such as the existence of water buoys in river bodies such as pillars, abutments and so forth. The phenomenon that occurs in the Sekanak river is the erosion and sedimentation around the bridge pillars. Erosion and sedimentation is a process that begins with the movement of the soil either floating or in the form of springboard at the bottom of the river, and when the soil becomes a fine particle, some will be left behind, and the other part is carried by the water flow and then into the water body or river to become sediment transport. For that purpose, the research was done by using the physical model approach on standard flume at the laboratory of Faculty of Engineering, Bina Darma University of Palembang. The result of the research showed that sediment movement pattern that happened around the Sekanak river bridge pillar is the plane bed and dune eroded or transition, with flow-down flow type phenomenon, slide flow, horseshoe vortex, and wake vortice while the total bedtime load around the pillar of the river bridge respectively with the formula of MPM  $tb = 18,44 \text{ m}^3 / \text{day}$ , Einstein and Lane  $tb = 9910 \text{ m}^3 / \text{day}$ , Frijlink  $tb = 1030 \text{ m}^3 / \text{day}$

**Keywords:** Musi river, Sekanak river bridge, sedimentation pattern, total bed load

## 1. Introduction

Palembang City is in the lowlands with a height of +2 m to +4 m d.p.l. Palembang city area is 402.50 km<sup>2</sup>. Where most of the area is in lowland areas of swamps. Palembang City is split by the river music and is located 85 km from the estuary with a river width of about 350 m and is still affected by tides of sea water as high as 2.5 m. During the rainy season, river water rises up to 1 m from the surface of the water during the dry season where the Musi River water level varies from +0.3 m to +1,8 m above sea level.

Musi River is the main river with a river length of more than 750 km, and the average width of 540 m is still affected by the tides of seawater from the thirteen existing river basin systems and one of the rivers in question is the Sekanak river where changes in the river sekanak this occurs as a result of factors nature and human factors such as the existence of water buoys in river bodies such as pillars, abutments and so forth. Dynamic nature of the river, a time will be able to affect the damage to the



buildings around it. Palembang's physiographic region lies in the lowlands of flood plains and includes the potential sediment areas as a pool of water.

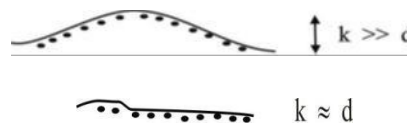
Potentials of this pool are factors that need to be considered for most areas of Palembang city. One of the problems that happened to Sekanak river is erosion and sedimentation around the bridge pillar in Sekanak river. Erosion and sedimentation is a process that begins with the movement of the soil either floating or in the form of springboard at the bottom of the river, and when the soil becomes a fine particle, some will be left behind and the other part is carried by the water flow and then into the water body or river to become sediment transport.

Changes in the river generally occur due to natural factors or human factors such as the existence of water buildings in the river body such as pillars, abutments, bending and so forth. Dynamic nature of the river, a time will be able to affect the damage to the buildings around it. One of the problems that occur in the river is sedimentation. Sedimentation process runs very complexly, preceded by the decrease of rainwater that produces kinetic energy as the beginning of the process of erosion on the soil surface. When the soil becomes a fine particle, some will be left behind, and the other part is carried by the stream and then into the water or river body so that it becomes sediment transport.

Based on the research, the greater the discharge flowing the sediment transport (Bed Load) will be more and more (Cahyono iksan 2007). The sediment transport at any given time will be deposited somewhere. Sedimentation can occur in river bodies or river estuaries.

### 1.1. Sediment transport mechanism

In a channel with a mobile bed base (a nonmoving cohesive sedimentary material), there will be an interaction between the flow on the ground as shown in figure 1, Flow changes may lead to a change in the basic configuration (roughness height). And conversely, the change of roughness will affect the flow itself.



**Figure 1.** Due to the flow of sand waves occur.

The basic configuration type depends on the nature of the flow and the material of the basic material (sand, gravel).

In the open channel, the Froude,  $Fr$ , is often used as a flow criterion. For classification of basic configuration (bed form), distinguished 3 regime flow, namely:

- 1) Lower flow regime ( $Fr < 1$ )
- 2) Transition flow regime ( $Fr \gg 1$ )
- 3) Upper flow regime ( $Fr > 1$ )

1. The flow velocity is still very small, the frictional stress,
2. The  $\tau_{ocr}$ , from the bottom is still not exceeded, and the sediment material is not / has not moved so that the basic sediment is still flat (plane bed).
3. This phase begins to occur sediment transport, then:

Pellets will move to roll, sliding or jumping randomly to space and time, If the sediment material is smooth, saltation, clouds, and suspended load may occur. As the speed increases, the intensity of the sediment transport increases, and a basic configuration is established. The basic configuration form that occurs in the lower flow regime usually has characteristics such as the dunes. The shape of the hill - the dunes are often known as ripples or dunes. Figure 2. shows the basic configuration of the sedimentation channel with the shape of the Ripple dunes, figure 3 shows the basic configuration of the sedimentation channel with Dunes dune shape, and Figure.

### 1.2. Shows the basic configurations

Channels that undergo sedimentation with the form of Bars sand dunes.



**Figure 2.** Forms of ripple sand hill.

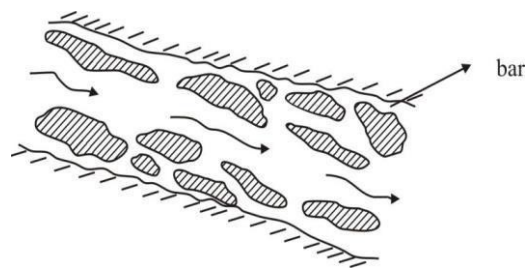


**Figure 3.** Forms of sand dunes.



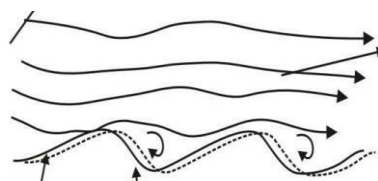
**Figure 4.** The shape of sand dunes bars.

Bars are usually formed at large discharge times and will appear as small islands at a small discharge (shallow water).



**Figure 5.** Dunes shape bars.

The steep slope on the downstream side of the dunes causes the separation of the flow so that the sand dune moves downstream and joins (into one) with the dunes downstream. So the length of dunes increases, the peak horizontal (bars), and the shape roughness decrease as shown in figure 6.



**Figure 6.** Erosion and sediment mechanisms.

Between the lower flow regime and the upper flow regime, there are transition conditions. In this condition dunes like cleaned (flushed). Basic irregular configuration of dunes to flat/plane bed.

If the flow rate continues to increase, the upper flow regime will be achieved. The first configuration forms observed were plane bed (sheet flow),  $k \gg d$ . As the velocity continues to increase, the water surface becomes unstable, and the bottom of the plane bed is changed to form antidunes sand waves.

If the Froude number is not too large (though  $Fr > 1$ ), the water level is only wavy (antidunes standing wave), but if  $Fr$  is very large, the wavy surface will grow, become unstable and break

(antidunes breaking wave) . When this happens, the anti dunes form is damaged, and the base becomes flat again. Very strong antidunes activity will produce chutes & pool flows.

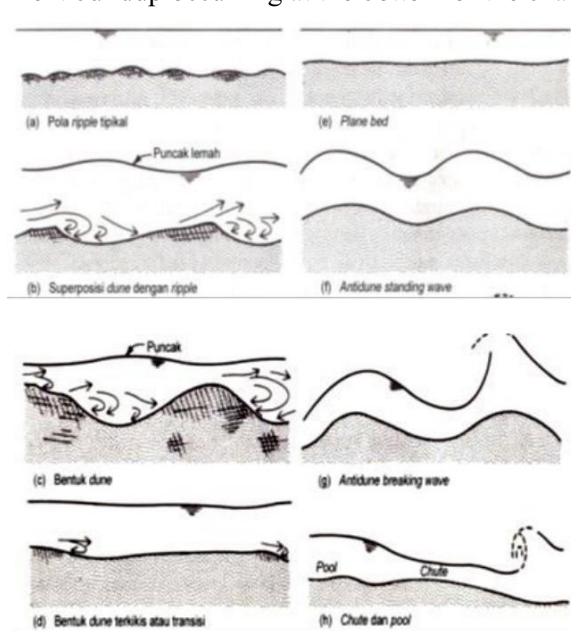
When the dunes become one, the sand dunes will be very large by the size of the channel width. This form is known as the bars. Bedforms classification and other information on bed material sedimentation are shown in table 1.

**Table 1.** Classification of bedforms and other information

| Flow regime  | Bedform          | Bed material concentrations, ppm | Mode of sediment transport | Type of roughness            | Roughness, $C/\sqrt{g}$ |
|--------------|------------------|----------------------------------|----------------------------|------------------------------|-------------------------|
| Lower regime | Ripples          | 10-200                           | Discrete steps             | Form roughness predominates  | 7.8-12.4                |
|              | Ripples on dunes | 100-1,200                        |                            |                              | 7.0-13.2                |
|              | Dunes            | 200-2,000                        |                            |                              | 7.0-20.0                |
| Transition   | Washed-out dunes | 1,000-3,000                      |                            | Variable                     | 7.0-20.0                |
| Upper regime | Plane beds       | 2,000-6,000                      | Continuous                 | Grain roughness predominates | 16.3-20                 |
|              | Antidunes        | 2,000 --                         |                            |                              | 10.8-20                 |
|              | Chutes and pools | 2,000 --                         |                            |                              | 9.4-10.7                |
|              |                  |                                  |                            |                              |                         |

(Source: Simons et al., 1965-1966, in the book Hydraulics of Sediment Transport)

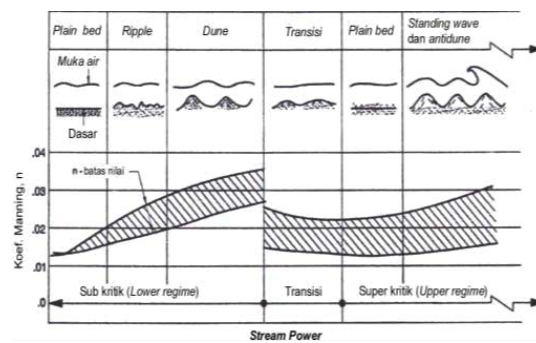
The various forms of sediment buildup occurring at the bottom of the channel are shown in figure 7.



**Figure 7.** Form of sediment stacking on a channel basis.

(Source: Simons et al, 1965-1966, in the book Hydraulics of Sediment Transport)

The various basic sediment surface forms that occur at the bottom of the channel based on the type of flow that flows on the channel are shown in figure 8.



**Figure 8.** The Surface Form of Sediments corresponds to the type of flow that flows on the channel.

## 2. Material and methods

This research was conducted by using simple flume physical model (figure 9) in the laboratory of Faculty of Engineering, Bina Darma University of Palembang

In this study used some tools and materials that are used for the manufacture of channels and observations during the simulation took place.



**Figure 9.** Flume physical model.

Water used in this research is water obtained from the Hydraulic Laboratory and Water Resources Department of Civil Engineering, Faculty of Engineering, Universitas Bina Darma. The sedimentary material used is the sandstone sediments of the king then the sand is washed and dried to clean from the mud and the dirt and sand used as later sieved with the sieve number 20. It is a major tool in the hydraulic jump, scouring and sediment experiments. This volume, most of the components are made of glass and have important parts, namely:

Waterways, the main place in this experiment, to drain water. A form of water flume with size 400 x 20 x 15 cm. Transparent walled water channel to facilitate observation, Container tub that serves to hold water to be flowed to the flume or out of the channel,

Water pump serves to pump water to be distributed along the gutter. This pump is equipped with an automatic on / off button for power supply 220/240 V, 50 Hz,

Discharge faucet is a faucet that functions to regulate the size of the discharge coming out of the pump. Have a 6-9 range discharge opening scale,

The tilt adjusting wheel, located on the upstream and downstream channels that can be rotated manually to adjust the desired slope of the bed. The bed slope control wheel has a scale for maximum positive bed slope + 3.0% and maximum negative bed slope - 1.0%

### 3. Results and discussion

The type of flow that occurs can be distinguished from the Froude number, which determines the flow to include a critical, subcritical, or supercritical stream.

$$Fr = U / \sqrt{g \cdot h} \quad (1)$$

with:

Fr = Froude number

U = flow velocity (m / sec)

g = acceleration of gravity (m / sec<sup>2</sup>)

h = flow depth (m)

$$Fr = 1.01 / \sqrt{9,81 \cdot 2,4} = 0.24$$

Mean flow type is Subcritical flow with Froude number <1

Flow behavior can be distinguished using Reynolds numbers, with categories of laminar flow, turbulent, or transition flows.

$$Re = UL / \nu \quad (2)$$

with:

Re = Reynolds number

U = flow velocity (m / sec)

l = characteristic length (meters)

$\nu$  = kinematic viscosity (m<sup>2</sup> / s)

$$Re = (1.01 \times 400) / 1.003 = 402.79$$

Means the flow type includes laminar flow with Reynolds number <500. Sediment Movement Pattern on pier brige of Sekanak river.



**Figure 10.** Sediment movement pattern during t = 30 '.



**Figure 11.** Sediment motion pattern during  $t = 60'$ .



**Figure 12.** Sediment motion pattern during  $t = 90'$ .



On the observation above sediment pattern that occurs on the pier of the sekanak river, bridge direction looks diverse, this happens because many factors that affect the process of sediment distribution around the piers of the river bridge include: (1). population of delta deposits that come at the time of highs and lows, (2). stream flow that the direction of its wave back and forth, (3). the small water velocity causing sediment particles of a larger size will be more easily deposited while smaller sediment particles will be deposited around the pier.

From the model simulation results show the sediment pattern that occurs erode on the side of the pillar and accumulate in front of the pillar, it shows that the speed of water affect the sediment pattern.

The shape of the sediment surface that occurs at the base of the channel based on the type of flow flowing around the pillar is the plane bed and the dune eroded or transition. Observation Relationship of Flow Patterns and Scouring Patterns

The flow pattern is very influential on the scour pattern that occurs. The whirlpool phenomenon that occurs around the pillar is the result of a collision by flow particles that interact on the bridge pillar model that occurs due to the high-speed flow found on the surface that is blocked by the pillar model of the bridge.

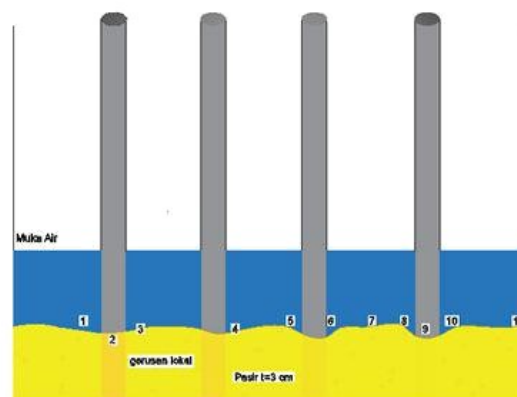
In the flow that leads vertically will move down from the surface to reach the bottom of the channel. Next press the water under it and create a vortex on the front of the pillar, this vortex will crush the basic sediment around the pillar with the phenomenon of horseshoe vortex. While the flow that moves the horizontal direction that passes through the side of the bridge pier will form the back vortices (wake vortices) that occur on the back of the pillar. This is due to the difference in flow velocity between the back of the pier and the flow flowing through the side of the pier.

Based on the type of bridge pillar used type 4 cylinder has a flow type phenomenon of down flow, slide flow, horseshoe vortex, and wake vortices.



**Figure 13.** The hydrodynamic phenomenon of flow on the pillar.

The relation of the flow pattern to the local scouring pattern that occurred was observed after running, and sketching was done. For more details, it can be shown in figure 13.



**Figure 14.** Local scouring pattern on 4-cylinder pillar.

In figure 14 above, the local scour pattern around the parallel 4-cylinder pillar is the same for the position of the pillar parallel to the direction of the incoming stream, the scour depth increases with increasing debit in time, the local scour pattern around the pillar whose position forms an angle to the flow direction which comes

From the calculation result of sediment base transportation done by using the formula of MPM, Einstein, and Lane, Frijlink obtained a result like the table below.

**Table 2.** Total bedload sediment per days.

| Location                                | MPM Tb<br>(m <sup>3</sup> /day) | Einstein<br>and<br>Tb<br>(m <sup>3</sup> /day) | Lane FrijlinkTb<br>(m <sup>3</sup> /day) |
|---|---------------------------------|--|--|
| Pillar<br>Bridge of<br>Sekanak<br>River | 18,44                           | 9910   | 1030                                     |

**Table 3.** Total bedload sediment per month.

| Location                                | MPMTb <sub>3</sub><br>(m /month) | Einstein<br>dan Lane<br>Tb<br>(m <sup>3</sup> /mont<br>h) | Frijlinktb <sub>3</sub><br>(m /month ) |
|---|----------------------------------|---|--|
| Pillar<br>Bridge of<br>Sekanak<br>River | 553,2                            | 297300  | 30900                                  |

**Table 4.** Total bedload sediment per years.

| Location                               | MPM tb <sub>3</sub><br>(m /year) | Einstein<br>danLane<br>tb (m <sup>3</sup> /year) | Frijlink tb <sub>3</sub><br>(m /year) |
|--|----------------------------------|--|---------------------------------------|
| Pilar<br>jembatan<br>Sungai<br>Sekanak | 6638,4                           | 3567600  | 370800                                |

#### 4. Conclusions

Sediment patterns that occur around the Sekanak river bridge pillar are a plane bed and dune eroded or transition, with flow type down flow, slide flow, horseshoe vortex and wake vortices phenomena.

In the recapitulation of sedimentary sediment transport that has been done with the formula of MPM, Einstein and lane, Frijlink obtained the amount of total bed load around the pillar of the river bridge respectively respectively MPM tb = 18,44 m<sup>3</sup> / day, Einstein and Lane tb = 9910 m<sup>3</sup> / day, Frijlink tb = 1030 m<sup>3</sup> / day.

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