The effect of flow velocity on local scaling around hexagonal pillars (laboratory model test)

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Abstract. The river has a dynamic nature that subject to change in the dimensions of space and time of. At the time of the balanced condition, the flow would be troubled by a pillars of the bridge and will form a more balanced condition caused scours the base. Scour around bridge pillars caused by the vortex system. This research will study the local scour depth at piers with two types of models (pillar 2 and pillar 3). Scour depth around pillars were observed for 15 minutes, 30 minutes and 50 minutes is done on a set of recirculating sediment on land lines with a length of 20 meters, width of 0.5 meters and height of 0.20 meters with a permanent uniform flow conditions. The model used is the type pillar with a hexagonal cross-section dimensions of 10 cm long, 5 cm width and 3.5 cm sloping sides. Scour depth measured each consisting of running time variation. The flow velocity was measured at each pillar around which causes the variation of maximum scour occurs.

1. Introduction
The bridge is one of the important infrastructure, maintaining the function and ability of the bridge in serving the traffic flow to be the key of the smoothness of the economy, therefore continuous inspection of the bridge condition must be an integral part in the bridge management system. Inspection of the condition of the bridge is intended to identify as soon as possible damage so that effective and efficient handling can be done in accordance with the conditions of damage that occurred. Damage to bridges can be caused by load factors, environmental and natural disasters.

The collapse of a bridge is largely due to the failure of the stability of the bridge pillar in transferring the bridge loads to the ground. The failure of the pillar is caused by scouring on the river bed or around the bridge pillar beyond the security level, thus endangering the construction of the bridge [1].

Scouring occurs usually lasts for long periods of time, as this process occurs gradually bit by bit. The process will look more real in the event of a major flood, it is based on when the floods occur, water fluctuations are no longer predictable. The basic scouring becomes even greater if the effective width of the river is reduced, this may result in the flow of water becoming focused towards a point.

Many cases of the collapse of bridge buildings are not only caused by construction factors, but the scouring problem around the pillars can be another cause, this is indicated by the continuous scouring process resulting in a decline in the base of the pillar [2].

Local scouring occurs due to the turbulence of water caused by the disruption of the flow, both large and its direction, resulting in the drift of basic materials or river cliffs [3, 4]. Turbulence is caused by changes in velocity to place and time. Local suction on the base material can occur directly by the flow
velocity so that the material's endurance is exceeded. Theoretically the shear stress that occurs is greater than the critical shear stress of the bed materials.

In order to overcome this phenomenon, it is necessary to study the laboratory about the total scouring that occurs around the pillar to know the scouring process that occurs, and to know the flow parameters that affect the local scour around the bridge pillar so that further can be searched for the control and prevention of scouring on the pillar for damage and collapse of construction can be avoided.

The purpose of this study is to analyze the effect of the flow velocity on scouring occurring around the pillar, as well as the form of scour changes occurring on the river bed caused by flow velocity and flow. This result is expected to be a reference in planning the pillar of the bridge so that the failure of the stability of the lower pillar of the bridge can be avoided.

2. Methodology

The research was conducted at the River Laboratory Civil Engineering of Hasanuddin University and Soil Mechanics Laboratory Muhammadiyah University of Makassar. The pillar model used is a Hexagonal-shaped pillar model made of stone ash and cement that is pressed on a plate-made steel plate with a size of 2 cm x 5 cm x 40 cm with a 3.54 cm slope. The pillar is placed in the center of the channel at a distance between the 2.6 m for pillar type 1 (2 pillars) and figure 1(b) 1.6 m for pillar type 2 (3 pillars).

![Figure 1. The hexagonal pillar shape.](image)

Determination of independent variables and bound variables, namely: In this running the free variable used is the time variation for drainage: $t_1 = 15$ minutes, $t_2 = 30$ minutes, $t_3 = 50$ minutes, channel width ($B$), channel length, channel slope ($S$), shape and size of pillar. The dependent variable is discharge ($Q$), streaming rate ($v$), and flow depth ($h$). In this running will be placed 2 (two) pillars with the distance between the pillars 2.6 cm in the middle of the channel with three variations of discharge ($Q$), namely: $Q_1$, $Q_2$ and $Q_3$ with each of three variations of time ($t$), namely: $t_1 = 15$ minutes, $t_2 = 30$ minutes, $t_3 = 50$ minutes. In this run will be placed 3 (three) pillars with the distance between pillars 1.6L in the middle of the channel with three variations of discharge ($Q$), namely: $Q_1$, $Q_2$ and $Q_3$, with each of three variations of time ($t$), namely: $t_1 = 15$ Minutes, $t_2 = 30$ minutes, $t_3 = 50$ minutes.
3. Results and discussion
This section explains and discuss the result into several subsections as follow.

3.1. Froude numbers
Froude numbers is a comparison between the force of inertia and the force of gravity. Thus, the Froude number is a function of all the event flow patterns in the channel. It is true that the Froude number is very important in determining the flow conditions in critical, subcritical, or supercritical streams. From the calculations it is seen that the Froude number is less than one, meaning that the current state of flow produces a subcritical flow condition can be seen figure 2.

![Figure 2. The relationship between flow velocity and Froude numbers.](image)

3.2. Observation of depth of scouring on debit
Measurement of scour depth around the pillar is done on three sections: front, side and back of pillar with Total observation point 375 observation points, 15 grid / yarn pias with each thread marked 25 point with distance between point two centimeter, to get Accurate contour data. Observation points around the pillar and the distance of pillar placement can be seen in figure 3 and figure 4.

![Figure 3. Pattern of point measurement for type 1 (2 pillars).](image)
Flow pattern that occurs in the middle of the channel there is a barrier in the form of pillars will result in local scouring (local scouring) and the decrease of base elevation (degradation) around the pillar. At the point of observation pillars as a model in obtaining scour conditions on each observation. Namely in the following picture, can be seen figure 5, figure 6 and figure 7.

**Figure 4.** Pattern of point measurement for type 2 (3 pillars).

**Figure 5.** Relationship discharge \((Q)\) with scour depth at time \((t) = 15\) minutes.

**Figure 6.** Relationship discharge \((Q)\) with scour depth at time \((t) = 30\) minutes.
Figure 7. Relationship discharge (Q) with scour depth at time (t) = 50 minutes.

Three images above, variations of flowing discharge at the same time indicate the local scour rate around the pillar. In the observation of figure 7 with a flow time of 50 min, the maximum scaling depth was greater than 4.9 cm, while the observation in figure 5, with a flow time of 15 min, experienced a smaller scouring depth of 2.7 cm. To change the scour depth at each different discharge, we can see on one of the picture above, in figure 7, visible depth scour which happened at variation of debit with the same running time that is, at P3 Pars of maximum scour depth which happened for 2.7 cm, at P6 pore the maximum scour depth that happened at 3.7 cm and at P8 pala the maximum scour depth which happened 4.9 cm. It can be assumed that of the three pias, the scour depth increases with increasing or increasing variation of discharge.

3.3. Observation of scour depth (ds) to flow velocity (v)
The effect of flow velocity variation on the local scour depth around the pillar can be seen in the following figure 8, figure 9 and figure 10.

Figure 8. Effect of flow velocity on local scour at station 10 (t = 15 min).

The effect of velocity variation due to different discharge with the scour depth is shown in figure 9. At time (t) 30 minutes with velocity (v) = 0.475 m/s obtained by a scour depth value of 4.6 cm at station 10 grid to 8, at velocity (v) = 0.525 m/s obtained scaled depth value of 6.2 cm at station 10 grid 8 and at velocity (v) = 0.573 m/s obtained scaled depth value of 6.9 cm at station 10 grid 8. The observation of the scour depth process shows the magnitude of the addition of scour depth at the beginning of the drainage, and then the addition of scour depth decreases as it approaches the balance into the scour.
4. Conclusions
Flow velocity will result in local scouring and decrease of base elevation (degradation) around the pillar which is a direct result of interactions between pillars, flow velocity, and bed materials. The existence of the pillar resulted in the stacking of the pressure (stagnation pressure) on the pillar, consequently the two-dimensional flow into three dimensions that have two streams namely downward flow along the upstream side of the pillar and horseshoe vortex around the pillar. The scour depth increased rapidly in the early minutes of drainage and the depth of the scour depth decreased to near balance.

References
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