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An experimental study of clay soils for preliminary data for scour model in open channels

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Abstract. Measuring building is one of the water construction buildings known as the sluice gate which serves to divide water according to the planned discharge by adjusting the water level. This building causes differences in inflow conditions in the upstream and downstream doors which results in the occurrence of scour around the measuring building which can endanger the construction. This research aimed at the analysis of the compressive strength of clay soil to make the scouring model on an open channel. The result showed the compressive strength of clay soil was 0,95 kg/cm². It is expected that the results of this test will result in interactions between the factors causing changes in flow patterns from a model that directly affects scour.

1. Introduction

The process of grinding and transporting sediment is a natural phenomenon that exists and occurs in the river flow. The grinding process can occur naturally as part of river morphology, in the form of a bend or narrowing of the flow, and can occur also due to the existence of river buildings (man-made structures) that block the flow, in the form of cribs, pillars, bridge abutments and so on. The existence of the river building is considered to be able to change the geometry of the flow and the flow pattern of the river. The scour can be divided into 3 (three) types, namely general scour, local scour, and localized scour (localized/constriction scour). General scouring in the river channel is not related at all to the presence/absence of river buildings. Local scouring around the building occurs due to local flow patterns around the river building. Scouring is localized in the river channel, occurs Because of the narrowing of the river channel, the flow becomes more centralized [1].

This phenomenon can cause erosion and degradation around water structures. This degradation takes place continuously until the balance between supply and sediment transport is mutually improving. The existence of changes in flow patterns, there is an imbalance between the amount of sediment transport that is greater than the supply of sediment. This causes a deeper scour hole.

Many cases of the collapse of the Air building are not only caused by construction factors but scouring around water building also can be another cause, this is indicated by the continuous erosion process resulting in a decrease in the building. The impact of local scouring must be watched out because it can affect the stability of the building's water stability. Considering the complexity and importance of the above problems, it is necessary to study local scouring around the water structures in the river due



to scouring effects. Based on the above description, it is necessary to conduct research to study local scour that occurs around the water building.

Soil work is a fundamental part of civil infrastructure development. KIMPRASWIL in 2002 release data about soft soil distribution in Indonesia, where this area establishes more than 20 million hectares or it almost 10% of the Indonesia region. This condition will become a major problem in construction because soft soils have a low bearing capacity and high compressibility. Meanwhile, a material with high compressibility is easy to deform because of loading or displacement [2].

2. Material and method

2.1. Local scour analysis

As stated earlier, local scouring events are actually quite complicated, as seen by the many influential factors. The factors that influence the local scour include the following: Basic slope of the channel characteristics of the transverse channel characteristics of local channel material characteristics of sediment transported by flow hydrograph characteristics and previous flood-flood history Flow direction at the bottom of the channel as a function of channel depth Characteristics of the building the water in question, for example the function of the channel depth. The base size that can be measured in a flow is the mean speed and shear stress. The effect of flow turbulence fluctuations eddies current formation can only be evaluated qualitatively. In most cases, the influence of the geometry of a building's water can only be accurately evaluated with a physical model or mathematical model. The durability of the base material against scour is a function of grain size and grain layout. The effect of adhesion or cohesion in local scouring phenomena is more difficult to analyze because of the complex material properties, even for non-cohesive materials, form factor parameters and grain layout factors are often overlooked because of the complexity of the problem.

Quantitative evaluation is usually done empirically. The study defines N sediment numbers and explains the scour phenomenon as a number function of this Ns [3].

$$N_s = \frac{u}{\sqrt{\left(\frac{\gamma_s}{\gamma} - 1\right)gD_g}} \quad (1)$$

Where:

- u : Speed of water near the base
- γ_s : Specific weight <base material
- Og : A typical diameter of the surface layer

Laminar and turbulent forced convection processes through in – lane tube banks study, for can be assumed as speed average V [4], so that is obtained equation 2.

$$N'_s = \frac{V}{\sqrt{\left(\frac{\gamma_s}{\gamma} - 1\right)gD_g}} \quad (2)$$

Where Dg is considered equal to the average geometry size of the sediment composition. On the other hand, another study formulated a formula that connected the characteristics of scour holes with flow characteristics [5]. This analysis begins with a continuity equation as shown in equation 3.

$$t = \int_b^s \frac{dV_s}{Q_s} \quad (3)$$

Where:

- Vt : Volume of scour hole
- t : Time
- s : Depth of scour hole
- Qt : Sediment raised from the scour hole

The flow after the sliding door undergoes a subcritical to supercritical change. In a more downstream location, an event is called a hydraulic jump. Jumping water has the characteristic of eroding flow. The existence of a sliding door causes the possibility of scouring on the channel downstream of the sliding door. Therefore, it is necessary to calculate the design of the channel at the downstream channel to be resistant to scouring due to the sliding door. Until now there is no exact formula that can be used in determining the depth of local scouring. Existing formulas are very limited by the conditions at the time of determining the formula. Formulas only apply to certain forms of constraints, certain construction sizes and types or properties of eroded riverbed material. The formulas below are the Schocklitsch, Varonese, Wu, Eggenberger Muller, and Kotoulas formulas. The parameters entered in the formulation are limited to:

$$f(q, v, H, d, g, ds, D) = 0 \quad (4)$$

Where:

q : Wide unity debit

v : Flow velocity

H : Total head between upstream and downstream water level

D = h : Depth of downstream water level

ds = T : The deepest grinding below the water face downstream after equilibrium is achieved

2.2. Clay soil

The quarry of soft soil samples using in this research was excavated from the University of Hasanuddin development site in Gowa as shown in figure 1a. Visually, soil samples colored with reddish-brown with a fine grain as shown in figure 1b. The basic properties analysis of soil presented that the soil classified as clay with high plasticity (CH) based on USCS standard. Properties of soil presented in table 1. Figure 2 shows the result of the sieve analysis. The general properties of laterite soil can be classified into the A-7-5 group according to ASTM D-427.98 [6].



Figure 1. (a) Soil sample quarry (b) clay soil visualization.

Table 1. Physical properties of clay soil.

Physical properties	Value
Specific Gravity (Gs)	2.705
Water Content	38.63%
Plasticity Index (IP)	40.27
Liquid Limit (LL)	71.77 %
Plasticity Limit (PL)	31.51 %
Classification	CH

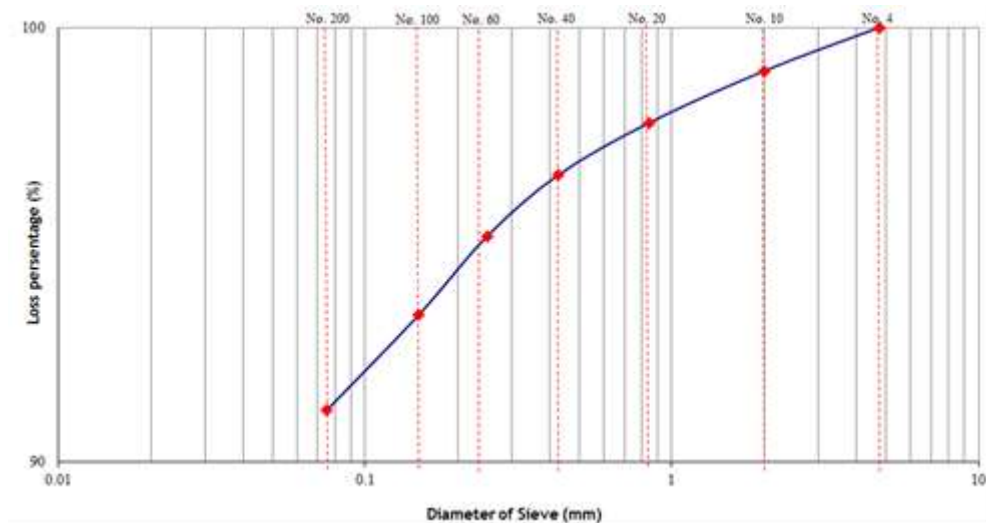


Figure 2. Gradation of soil.

2.3. Testing procedure

Compressive strength testing was carried out by using a universal testing machine (UTM) with the strain speed 0.3 mm / minute. In addition to obtaining maximum tension, the strain that occurs due to loading is also measured by installing LVDT at the time the test is carried out. The effect of curing time on compressive strength for each specimen is carried out, wherein this study the compressive strength value.

UCS test was conducted according to SNI 03-6887-2002 [7]. Figure 3 shows the UCS test in the laboratory. The soil samples for UCS test were prepared using cylindrical molds, which have an inner diameter of 5 mm and a height/diameter ratio of 2.0 for reducing the end effects during UCS testing. Three replicates of each sample set were prepared to assure reproducibility.



Figure 3. Equipment of UCS test in a laboratory.

3. Results and discussion

Based on the results of the compressive strength of clay soil were to determine the stress (q_u) and strain (ϵ), the relationship between stress and strain values is shown in figure 4. Tests showed that the reliability of a test object in accepting the existing load. The smaller the weight loss that occurs in the test object means the more resistant and stronger the test specimen. Figure 5 shows the morphology of the test object before and after wear testing of the compressive test, respectively.

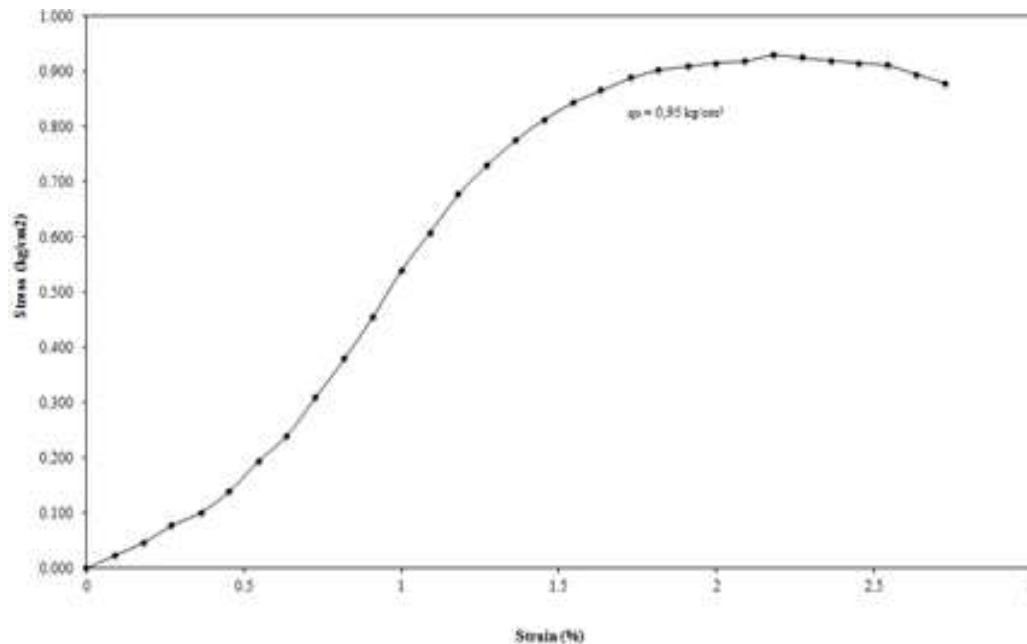


Figure 4. Relationship Stress-Strain Value.



Figure 5. Morphology of Specimens After Compressive Test.

Based on figure 5 it can be seen that the maximum stress obtained from the compressive strength of the clay used in the research of the open channel scour model is 0.95 kg/cm^2 . The specimen illustrates that the compression stress of treated soil increased with an increase in axial strain up to a certain peak. After reaching the peak strength, the unconfined compression stress was stable while the axial strain increase and strain softening occurred prior to fracture. It is evident that treated soil with lime and cement has ductile behavior in compression.

4. Concluding remarks

Based on the results, the potential utilization of clay soil used in the research of the open channel scour model. Curing time has a significant effect on the increase of the compressive strength test of the clay soil.

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