The Effect of Sediment Particle Size to Sedimentation in Culvert Box (Culvert MEL)

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ABSTRACT— ***The Drainage is complement structure which also controls the rainwater flow system to run safely through the streets, the stiff area turns, culverts, channel junction, waterfall structure, bridges, water ropes, pumps, and sluices. Culvert Box (Zo), affect sedimentation level. The result was expected to be useful for drainage system planning to take action in anticipating sedimentation. Therefore, the drainage channel can be used in long time. The research was conducted in Hydraulic Laboratory of Technique Faculty Hasanuddin University. The method was an Experimental method using Culvert MEL Model. The lower sedimentation The results shows that, in general, in total sedimentation that occurs in Culvert channel based on flow discharge for all channel with different flume base decrease level (Zo), the higher the discharge, the lower sedimentation occurred. The graphics also show that sediment particle size also affects sedimentation, where the bigger size of the particle was higher than sedimentation that occurred.***

Keywords— Culvert. Sedimentation

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1 INTRODUCTION

The Drainage is complement structure which also controls the rainwater flow system to run safely through the streets, the stiff area turns, culverts, channel junction, waterfall structure, bridges, water ropes, pumps, and sluices. Culverts are building a structure that is used to carry water flow (irrigation or damp channel) under another waterway (usually channels), streets or railways. Culverts are also used to run small river or as part of drainage or street gutter [1].

Drainage within the culverts needs the energy to push water through them. The energy is the difference between water surface level in headwater and downstream of the culverts. The depth of water surface in headwater that is measured from input base is water increase degree. Available energy will affect the flow. Puddles in the headwaters of the culvert (afflux) occur due to the lack of energies that are available, such as the area with the only slight basic slope. In addition, puddles also occur due to sudden construction of channel section [2]. Culvert MEL is square shape culvert with slight or even zero energy loss. The virtue of the Culvert MEL structure is to reduce the increase of water surface (afflux) in headwater of the culvert, therefore, minimize or obviate energy loss. The condition happens because the structure of culvert MEL is different from the regular culvert, wherein culvert MEL there is flow transition from drainage channel, and also, there is inverted in the culvert. Chanson [3] in his study of Hydraulic Performance of Minimum Energy Loss Culvert in Australia, propose the basic concept of Culvert MEL planning, the development of Culvert MEL within and outside Australia, and planning experience.

Akanmu and Gambo [4] research with two dimension Culvert MEL method, developed using terminate element method. The research concluded that in low flow period, sediment could persist in the bottom of the bottom culvert. Minimum Energy Loss was designed for 32 m3/sec water flow discharge. The width of bridge barrel was 7 m with opening channel width was 48.7 m and 42.0 m at the downstream. The physical model was undisturbed with the scale of 1/16, tested under sedimentation condition and sediment draining. Akanmu and Gambo [4] conducted simulation experiment of the limited element of flow through Culvert MEL. Model parameters were varied to determine the influence of energy loss. The parameters in the research were the slope of inlet and outlet, the length of the culvert, length of the barrel, inlet and outlet depth. The conclusions were: the influence of inlet and outlet slope, culvert length and depth, and barrel length to energy loss [5].

The decrease of Culvert MEL transition has the potency of sedimentation to occur which cause less quantity and capacity of the drainage. Basic limitations of MEL Culvert are minimum cost; minimum puddle that may happen in headwater and sediment draining can be performed well. Even though Culvert MEL is just a small construction but it is essential for drainage and road infrastructure integration. The important role of Culvert as the support of transportation system, the structure must be maintained to avoid the factors that may damage Culvert structure. One of the factors that may damage or lessen the function of the culvert is sedimentation problem where Culvert MEL might have high potency, due to its geometrical structure shape [6], [7].

The study aims to see and analyze how particle size of sediment and basic geometric change of Culvert Box (Zo), affect sedimentation level. The result was expected to be useful for drainage system planning to take action in anticipating sedimentation. Therefore, the drainage channel can be used in long time. The Box Culvert model that was used was the model used by the previous researcher who studied about the minimum energy of Box Culvert, with minimum basic decrease. Determination of the size and model scale was made based on space capacity and pump equipment that was available In the laboratory.

2 MATERIAL AND METHODE

To observe sedimentation that occur in Culvert MEL experimental research was conducted in laboratory using Culvert MEL model with 4 variation of decrease, which were: zo = 0.00 m; zo = 0.009; zo = 0.025 m and zo = 0.325 m. The research used sand as sediment material on Culvert MEL. The sand was categorized into three; they are, fine sand, medium sand and coarse sand, with diameter, successively, 0.26 mm, 0.31 mm and 0.62 mm. Flow tests were conducted using three variations of flow discharge, which is 0.00058 m3/sec, 0.00075 m3/sec, and 0.00095 m3/sec. The research can be used to observe sedimentation that occurs in Culvert MEL and study the correlation between the size of the sediment particle and geometrical shape of the culvert base and flow parameter. This research is experimental laboratory method. This method is considered to be effective for studying the effect of sedimentation particle size to sedimentation in Culvert Box (MEL)

The modeling is preceded by a standard culvert building prototype design as well as an MEL. Based on the design of prototype has design prototype, the model is made with a 1: 20 model scale. Box culvert model consists of channel and transition of upstream, flume, and downstream transitions. Upstream channel of trapezoidal trunk, base width Bs = 0,005 m, high water h = 0,084m , high guard w = 0,036 m, slope m = 1,5 m, based channel slope I = 0,003. Length of upstream = 75 cm, Upstream transition = 40 cm.

The downstream channel dimension is made equal to the upstream part, the length of the downstream portion is 25 cm downstream channel, downstream transition = 50 cm. The flume portion is a four-square-sectional channel that presents the Box Culvert model, with length = 1.00 m. The research was conducted from May to Agustus 2016 in Hydraulic Laboratory of Hasanuddin University of Makassar.

Figure 1: Installation Culvert Model on Observation Table

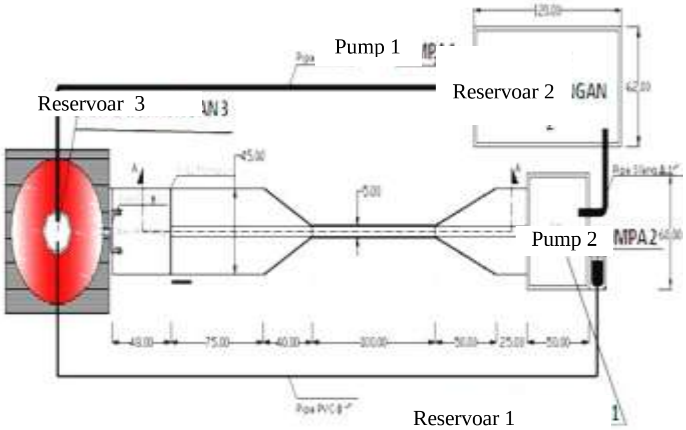

Figure 2: Plan of Culvert Model

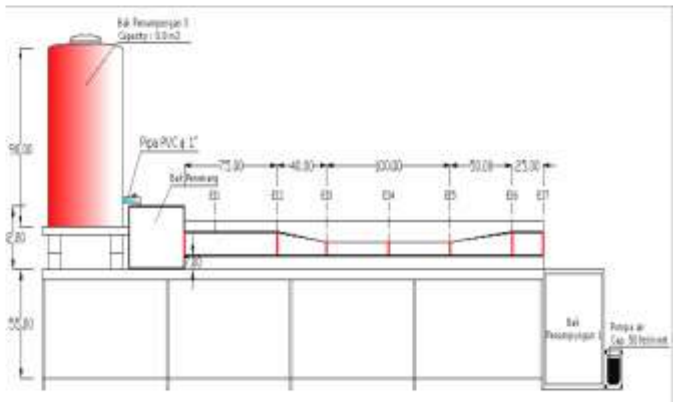

Figure 3: Side View Culvert Model

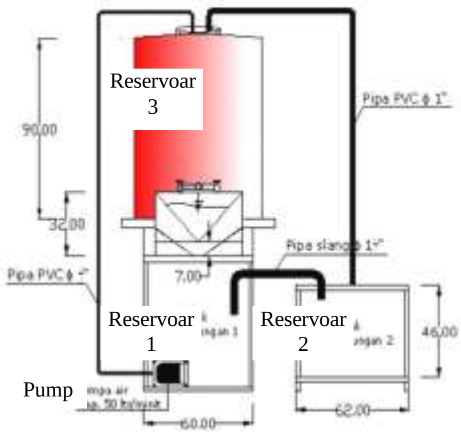

Figure 4: Front View Culvert Model

Determination of discharge conducted through observation Thomson thrift gauge placed downstream of a tranquilizer. This measuring instrument is a triangular threshold triangle with a 90º angle. Determination of the discharge is done by observing Thomson thrift gauge put on the downstream of the tranquilizer. This measuring instrument is a triangular threshold triangle with a 90º

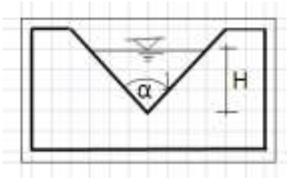

Figure 5: Thomson Inlet

The amount of discharge passing through the Thomson door is calculated by the formula:

$$Q = \frac{8}{15} C_d tg \frac{\alpha}{2} \sqrt{2g}\, H^{5/2} \qquad (1)$$

Where:
Q = Flow discharge (liter/second)
Cd = Flow Coefficient (obtained Thomson Instrument trial)
α = angle triangle
g = gravitation
H = Water high in Thomson doo

Determination of the flow coefficient of flow is done by observing the flow discharge through Thomson door. The observations are repeated, so from this observation, the magnitude of the Cd flow coefficient can be calculated, as in Table 1.

Table 1: Determination of Flow Coefficient

No	Water High(h) (m)	Time (sec)	Discharge (Q) (m^3/sec)
1.	0.05	10	0.740
2.	0.05	10	0.776
3.	0.05	10	0.754
4.	0.05	10	0.703
5.	0.05	10	0.771
Average			0.749

The research in Laboratory implemented in the following stages:

- The fine, medium and coarse sediments that have been analyzed and weighed are prepared in advance.
- The first drainage is carried out on the Culvert Standard model with a Flume (Zo) bottom depth of 0.00 m with 0.00058 m3 / sec discharge.
- After stabilizing water, measurements of water level in some places are inlet transition mouth, flume mouth, mid flume, outlet transition mouth, outlet transition outlet and each at 3 (three) depths. Fine sand, medium sand, and coarse sand Which have been analyzed and weighed prepared in advance.
- The first drainage is carried out on the Culvert Standard model with a Flume (Zo) bottom depth of 0.00 m with 0.00058 m3 / sec discharge.
- After stabilizing water, measurements of water level in some places are inlet transition mouth, flume mouth, mid flume, outlet transition mouth, outlet transition outlet and each at 3 (three) depths.
- After the measurement, the sediment is then observed until the sediment stops moving.
- After streaming, sedimentation of sedimentation results are collected and separated, each of sediment on inlet transition, flume and transition outlet.
- Sedimentation results are dried to be analyzed and weighed.
- The treatment is repeated for different discharge (Q), i.e. 0.00075 m3 / sec and debit (Q) 0.00095 m3 / sec.
- After the treatment is completed, then it is repeated using Culvert model with different flume base size (Zo)

The water supply for research is taken from the second reservoir available, by pumping into the third shelter. From the third shelter is streamed into a tranquilizer with two faucets that function as a flow regulator. At the outlet of the drain is inserted into the first reservoir and then re-pumped into the third reservoir. Constant water surface conditions must be maintained.

3 RESULT AND DISCUSSION

In this research, sand is used as sediment material in Culvert MEL model. The sand used is grouped into three categories of grains of Fine, medium, and coarse grains. The three types of sand grains are analyzed in Soil Mechanics laboratory to know the average grain diameter and granular weight, the result is as follows:

Table 2: Sediment Analysis

Category	Average Particle Diameter (d50)	Specific Gravity
Fine Sand	0.26	2.788
Medium Sand	0.31	2.773
Coarse	0.62	2.712

Table 2 above seen that at a glance that the three types of sand have almost the same weight. Although the sand with fine grains (d50 of 0.26 mm) has the most significant density of 2.788 gr/m^3 then sand with medium grains (d50 of 0.31 mm) of specific gravity 2,773 gr/m^3 and coarse grain (d50 of 0.62) has the smallest density of 2.712 gr / m3.

According to the formula of the vapor speed i.e.

$$\omega_o^2 = \frac{4\gamma_s - \gamma g d}{3\gamma C_D}$$

where:

ω = speed of sediment
d = particle diameter
C_D = drag force(N)
γ_s = Specific Gravity
γ = heavy density of water
g = gravity

The specific gravity and grain diameter affect sedimentation, but the most significant effect on sedimentation is the specific gravity.

The flow velocity (V) in Culvert is an essential parameter in the study of sedimentation. Therefore, the flow velocity in inlet, flume and outlet transitions should be observed. The flow velocity is obtained by direct measurement on each channel model at 3 (three) places and three layers of depth. From these measurements, the flow rate data on flume can be seen in Table 3.

Table 3: Speed of Flow in Flume

High Thomson Door (m)	Discharge (m^3/s)	Channel Wide (m^2)	Speed (m/s)
0.045	0.00058	0.001	0.46
0.050	0.00075	0.002	0.53
0.055	0.00095	0.002	0.52
0.045	0.00058	0.002	0.38
0.050	0.00075	0.002	0.61
0.055	0.00095	0.002	0.45
0.045	0.00058	0.003	0.27
0.050	0.00075	0.003	0.31
0.055	0.00095	0.003	0.65
0.045	0.00058	0.003	0.22
0.050	0.00075	0.003	0.18
0.055	0.00095	0.003	0.31

Laboratory test results showed that sedimentation in flume area (inside the culvert) for three sizes of sediment (fine, medium and coarse sand) and presented in Table 4.

Table 4: Sediment Particle Size to Sedimentation in Various Decrease of Channel Base

Channel Base Decrease (m)	Flow Discharge (m3/s)	Sedimentation (gr)		
		Fine Sand	Medium Sand	Coarse Sand
0.000	0.00058	0.00	0.00	0.00
0.009		8.40	15.30	18.60
0.025		28.17	30.20	43.60
0.325		33.20	35.80	60.30
0.000	0.00075	0.00	0.00	0.00
0.009		6.12	12.11	15.00
0.025		25.97	28.34	27.84
0.325		27.84	30.43	54.97
0.000	0.00095	0.00	0.00	0.00
0.009		3.87	10.13	12.74
0.025		20.54	21.98	24.87
0.325		22.95	25.64	41.67

After getting data from the running model in the laboratory, then the data obtained then processed. From the results of actual calculations, data and then plotted on the graph to know the influence of some parameters studied against potential sedimentation. The next analysis is statistical analysis by using scatter diagram, to know the tendency of the effect of the variable of variables studied. Statistical analysis with scatter diagram is done by using spreadsheet presented in curve

The effect of particle size to sedimentation in a different base decrease for three variations of flow discharges is provided in Figure 1, 2 and 3.

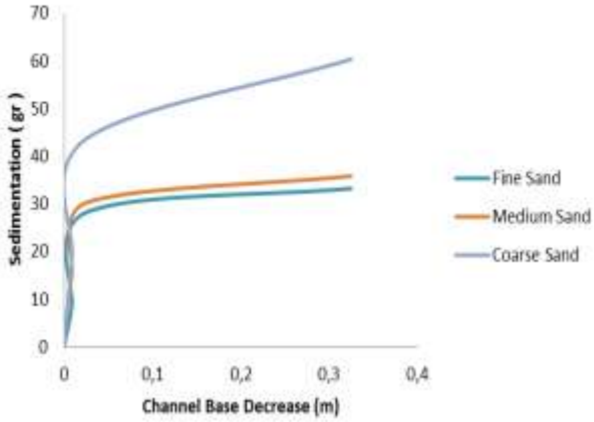

Figure 4: The Influence of Sediment Particle Size to Sedimentation in Various Decrease of Channel Base with Flow Discharge of 0.00058 m3/sec

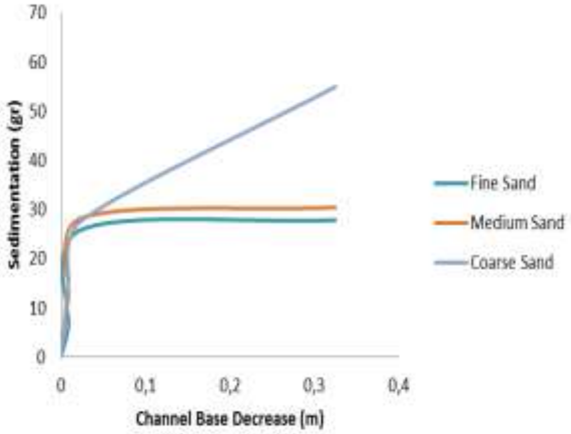

Figure 5: The Influence of Sediment Particle Size to Sedimentation in Various Decrease of Channel Base with Flow Discharge of 0.00075 m3/sec

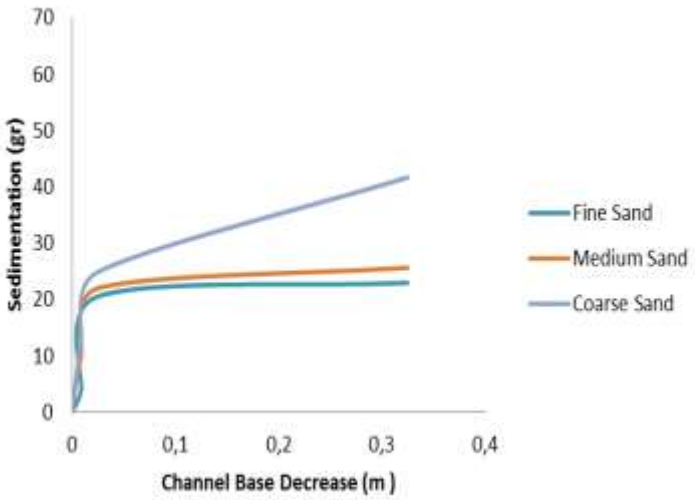

Figure 6: The Influence of Sediment Particle Size to Sedimentation in Various Decrease of Channel Base With Flow Discharge of 0.00095 m^3/sec

General total sedimentation that occurred in flume increased, along with the decreased of flume base (Zo), for all type of experimented type of sediment (fine, medium and coarse sand). The size of sediment particle also affects significantly to the sedimentation. The bigger the size of the sand, the higher the sedimentation occurred in the flume.

4 CONCLUSIONS

The sedimentation of the inlet region decreases with the decline in the base of flume (Zo) for all types of sediments attempted (fine sand, medium sand, and coarse sand). Sediment grain size is also quite a significant effect where the larger grain size of sediment the higher percentage of sedimentation that occurs in the inlet area. In the field of sedimentation, the flume is increasing with increasing the decrease of flume base (Zo) for all types of sediment being tried (fine sand, medium sand, and coarse sand). Sediment grain size also significantly influences where the larger grain size of sediment higher than sedimentation that occurs in the flume area

Sedimentation in the outlet area is increasing with growing base flume (Zo) for all types of sediments being tried (fine sand, medium sand, and coarse sand). Sediment grain size is also quite a significant effect where the larger grain size of sediment higher than sedimentation that occurs in the outlet area. The total sedimentation occurring in Culvert Standard (Z = 0.00 m). It is higher than the sedimentation occurring in Culvert MEL (Z = 0.009 m, Z = 0.025 m, Z = 0.0325 m) decreased at massive discharges In Culvert MEL, total sedimentation occurs increasingly at a significant decrease in the base of the flume (Zo).

Total sedimentation in Culver is increasing in diameter of large grains of sediment. The three Culvert MEL models used, specifically the observation of the sedimentation weight. The effective model used is with a 0.025 m - 0.0325 m base derivation (Zo) because based on the observation and analysis of sedimentation data obtained from drainage for Zo = 0.009 m Sedimentation that occurs large as well as for the primary decline (Zo) = 0.0325 m

5 ACKNOWLEDGMENT

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6 NOMENCLATURE

Zo	Channel base decrease	m
Q	Flow discharge	m^3/s
Cd	Flow Coefficient	
α	Angle of triangle overflowing	o
g	Acceleration of Gravity	m^2/sec
H	water level on the floodgate	m

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