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A Physical Model Approach to the Depth of Erosion in the Buah River, Palembang, Indonesia

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Abstract— The research was conducted to see the flow phenomenon in the river with hydroulic modeling, namely by using the river/channel scale model in the Bina Darma River and Hydraulics laboratory.

The Buah River, with the main river being 7.93 km long, has many meanders and a river wall reinforcement has been built. The average grain diameter (d_{50}) used in this study was 0.025 mm based on the sieve analysis carried out as sediment material at the time of modeling.

The results showed that the erosion depth at the bottom of the Buah river occurs at the beginning of the river/channel. Buah river is dominated by the river estuary, during the "running test" of 30 minutes, the greatest (maximum) erosion occurs so it is said that the optimum condition is erosion of 1.8 cm in the model and with a scale of 1: 100, the erosion that occurred in the field (prototype) was 1.8 m.

Keywords—The Buah river; bed load; scale models; erosion depht

I. Introduction

Palembang city has 108 tributaries. There are 4 major rivers that cross the city of Palembang, namely the Musi River, Komering River, Ogan River, and Keramasan River. Of the 4 major rivers above the Musi River is the largest river with an average width of 504 meters and a maximum width of 1,350 meters around Kemaro Island. (Achmad Syarifudin, 2018).

Based on the division of river areas, there are 21 sub-watersheds, but only 18 sub-watersheds in the city of Palembang which empties directly into the Musi river in the city of Palembang, namely the Rengas Lacak, Gandus, Lambidaro, Boang, Sekanak, Bendung, Lawang Kidul, Buah, Juaro, Batang, Sei Lively, Keramasan, Kertapati, Kedukan Ulu, Aur, Sriguna, Jakabaring and Plaju. (Department of PUPR of Palembang city, 2018; Achmad Syarifudin, 2022).

The urban drainage system which always experiences flooding in the city of Palembang every year, among others, is the Buah watershed area. Buah river with a main river length of 7.93 km, there are many meanders and river wall reinforcement has been built. The fruit sub-watershed with an area of 10.79 km2 is generally a residential, industrial and swamp area. (Ayu Marlina et al , 2020; Achmad Syarifudin, 2022).

The condition of the Palembang city area is relatively flat, so at certain locations it often experiences puddles (floods) caused by the flow of rainwater (run-off) which cannot be accommodated by the channel. In addition, at certain locations, puddles (floods) are also caused by the runoff of the Musi River. Floods that occurred in the city of Palembang caused problems for the Government to evaluate the existing drainage channels. The rainwater drainage channels have been built but need to be reviewed and evaluated to function properly. (Achmad Syarifudin, 2022).

Various efforts have been made, but these efforts have not been optimal in overcoming the problem of puddles (floods). These efforts are in the form of maintaining city drainage channels, cleaning river channels that cross the city. Likewise, studies related to flood control in urban areas, construction of flood control facilities have been made and several policies and regulations have been issued for flood control. These efforts turned out to be outpaced by the development of the city. (Achmad Syarifudin, 2018).

For this reason, it is necessary to conduct a physical model approach to the depth erosion in teh Bah river.

The complexity of the river system can be seen from the various components of the river, for example the shape of the river flow and branching, river bed form, river morphology, and river ecosystem. The river branch will resemble a river tree starting from the first order to the nth order river. The river bed formation, when examined at a glance, is very difficult to identify and characterize. The shape of the meander groove is influenced by the longitudinal slope of the landscape, the type of river bed material, and the vegetation in the area (Maryono, 2007; Achmad Syarifudin, 2022).

A river or open channel is a channel where water flows with a free water level. In an open channel, for example a river (natural channel), the flow variable is very irregular with respect to time and space. These variables are the cross section of the channel, roughness, bottom slope, curvature of the flow rate and so on (Triatmodjo, 2003).

II. RESEARCH METHODS

The research was carried out using the Hydraulics and Rivers laboratory at Bina Darma University with a laboratory scale (scale model) as shown in Figure 1.

Fig. 1. Research model in the laboratoy

2.1. Materials and tools

The materials used in this study include:

- the material used as the Buah river material is sand with a diameter of 0.025 mm to 2.36 mm. Before being used as experimental material, a sieve analysis was carried out to obtain a uniform grain diameter.

- to move the flow in the channel is water as well as to move sediment grains,

- The specifications of the tool are as follows:

-flexiglass for standard flume

- length of the channels: 4.00 m

- Width: 0.15 m

- Depth: 0.20 m

- the instrument meter used for scouring depth value.

- Photo camera to take pictures when doing the experiment.

- Video recorder to record experiment implementation.

2.2. Research preparation

This research was conducted using a laboratory approach method with various variations in the flow rate, flow rate and time. The standard channel (flume standard), most of its components are made of glass and have important parts, namely:

a. The aqueduct, the main place in this experiment, to drain the water. In the form of water flume with a size of 4.00 x 20 x 15 meters. This channel has transparent walls for easy to observed phenomena of the scoring depth,

b. A reservoir that functions to accommodate water that will be flowed into the channel or out,

c. Water pump, used to pump water so that it can be distributed along the gutter,

d. Discharge faucet, functions to regulate the discharge that comes out of the pump. Has a discharge scale of 6-9 range,

e. The tilt adjustment wheel, located upstream and downstream of the channel, can be manually turned to adjust the desired bed slope. This bed slope adjustment wheel has a scale for maximum positive bed slope + 3.0% and maximum negative bed slope - 1.0%.

III. RESULTS AND DISCUSSION

The results of the study get the value of the depth of erosion for each experimental length as shown in the following table and figure below:

TABLE I. EXPERIMENTAL RESULTS IN THE LABORATORY

t (time)	d_e (erosion depth)	x (distance)	x/t	de/t
minute	cm	cm		
5	0.9	6	1.20	0.18
5	1	15	3.00	0.20
5	0.4	28	5.60	0.08
5	0.4	45	9.00	0.08
5	0.7	54	10.80	0.14
5	0.3	68	13.60	0.06
5	0.5	80	16.00	0.10
5	0.4	82	16.40	0.08
5	0.4	93	18.60	0.08
5	0.2	100	20.00	0.04
5	0.3	118	23.60	0.06
5	0.5	131	26.20	0.10
5	0.2	136	27.20	0.04

5	0.2	147	29.40	0.04
5	0.2	157	31.40	0.04
5	0.3	176	35.20	0.06
5	0.2	192	38.40	0.04
5	0.2	382	76.40	0.04
5	1.2	392	78.40	0.24
10	1.7	5	0.50	0.17
10	2	7	0.70	0.20
10	1.2	16	1.60	0.12
10	0.4	52	5.20	0.04
10	0.9	38	3.80	0.09
10	0.5	60	6.00	0.05
10	0.4	86	8.60	0.04
10	1	101	10.10	0.10
10	0.5	119	11.90	0.05
10	0.6	154	15.40	0.06
10	0.4	172	17.20	0.04
10	0.1	187	18.70	0.01
10	0.3	208	20.80	0.03
10	0.6	229	22.90	0.06
10	1	234	23.40	0.10
10	0.2	243	24.30	0.02
10	0.2	296	29.60	0.02
10	0.1	350	35.00	0.01
10	0.1	356	35.60	0.01
10	1	387	38.70	0.10
10	1.5	396	39.60	0.15
10	1.9	398	39.80	0.19
15	0.2	9	0.60	0.01
15	0.1	33	2.20	0.01
15	1.1	45	3.00	0.07
15	0.5	63	4.20	0.03
15	0.4	75	5.00	0.03
15	0.7	86	5.73	0.05
15	0.7	96	6.40	0.05
15	0.2	107	7.13	0.01
15	0.6	111	7.40	0.04
15	0.5	127	8.47	0.03
15	0.3	153	10.20	0.02
15	0.4	162	10.80	0.03

15	0.1	178	11.87	0.01
15	0.3	198	13.20	0.02
15	0.3	215	14.33	0.02
15	0.2	239	15.93	0.01
15	0.5	380	25.33	0.03
15	1.1	393	26.20	0.07
20	2	10	0.50	0.10
20	0.9	23	1.15	0.05
20	1.2	31	1.55	0.06
20	0.9	40	2.00	0.05
20	0.8	56	2.80	0.04
20	0.7	65	3.25	0.04
20	0.4	75	3.75	0.02
20	0.3	83	4.15	0.02
20	0.2	91	4.55	0.01
20	0.2	105	5.25	0.01
20	0.1	112	5.60	0.01
20	0.3	120	6.00	0.02
20	0.4	124	6.20	0.02
20	0.3	139	6.95	0.02
20	0.3	151	7.55	0.02
20	0.5	163	8.15	0.03
20	0.1	181	9.05	0.01
20	0.3	225	11.25	0.02
20	0.2	234	11.70	0.01
20	0.1	243	12.15	0.01
25	2	7	0.28	0.08
25	1.9	18	0.72	0.08
25	1.4	29	1.16	0.06
25	0.9	36	1.44	0.04
25	0.8	46	1.84	0.03
25	0.4	53	2.12	0.02
25	0.8	57	2.28	0.03
25	0.4	64	2.56	0.02
25	0.6	71	2.84	0.02
25	0.5	81	3.24	0.02
25	0.4	88	3.52	0.02
25	0.5	94	3.76	0.02
25	1	100	4.00	0.04
25	0.3	105	4.20	0.01

25	0.2	111	4.44	0.01
25	0.3	119	4.76	0.01
25	0.1	126	5.04	0.00
25	0.2	132	5.28	0.01
25	0.6	144	5.76	0.02
25	0.2	155	6.20	0.01
25	0.3	163	6.52	0.01
25	0.1	181	7.24	0.00
25	0.3	230	9.20	0.01
30	2	8	0.27	0.07
30	2	18	0.60	0.07
30	1.8	23	0.77	0.06
30	1	26	0.87	0.03
30	1.8	33	1.10	0.06
30	0.6	46	1.53	0.02
30	1.5	47	1.57	0.05
30	0.4	64	2.13	0.01
30	0.3	71	2.37	0.01
30	0.6	90	3.00	0.02
30	0.5	91	3.03	0.02
30	1.5	97	3.23	0.05
30	0.5	99	3.30	0.02
30	0.3	109	3.63	0.01
30	0.2	117	3.90	0.01
30	0.4	120	4.00	0.01
30	0.6	133	4.43	0.02
30	0.8	148	4.93	0.03
30	0.3	164	5.47	0.01
30	0.1	173	5.77	0.00
30	0.2	192	6.40	0.01
30	0.1	235	7.83	0.00
30	0.1	237	7.90	0.00
30	0.2	248	8.27	0.01

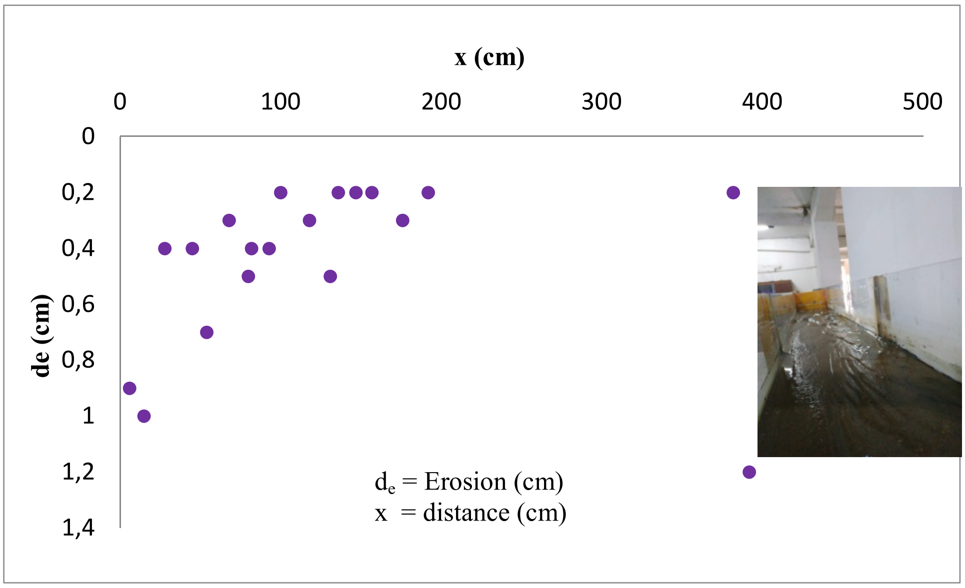

Fig. 2. Plotting The Results of the erosion depth (de) during the "running test" for 5 minutes

From Figure 2 above, it can be said that at the estuary of the river model, the erosion depth is quite large, namely 100 mm and then continues to decrease at a distance of almost 200 cm and then increases again by 1.2 cm. The length of the experiment is 5 minutes.

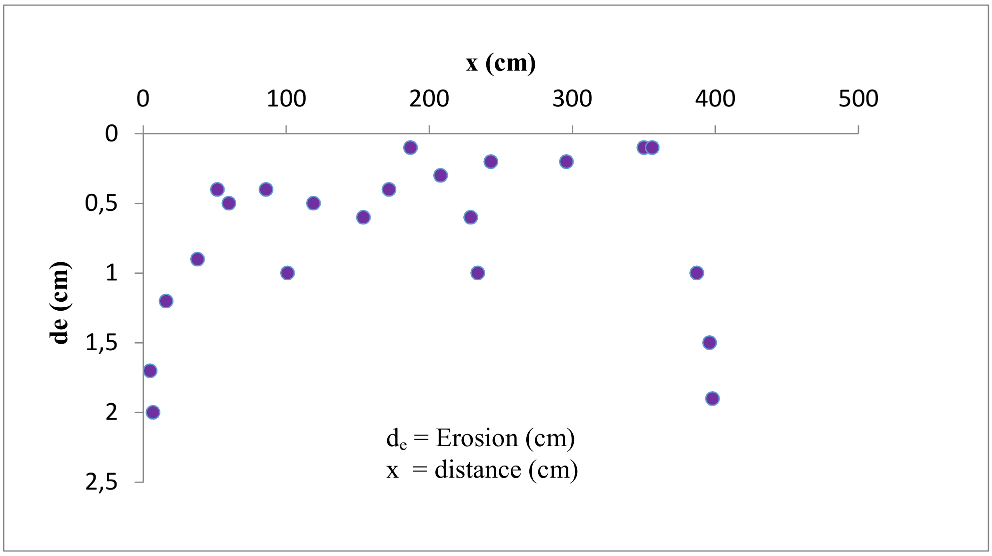

Fig. 3. Plotting The Results of the erosion depth (de) during the "running test" for 10 minutes

From Figure 3 with an experimental time of 10 minutes, it can be said that the river estuary model obtained an erosion depth of 200 mm and then continued to decrease at a distance of almost 350 cm and then increased again by 1.8 cm.

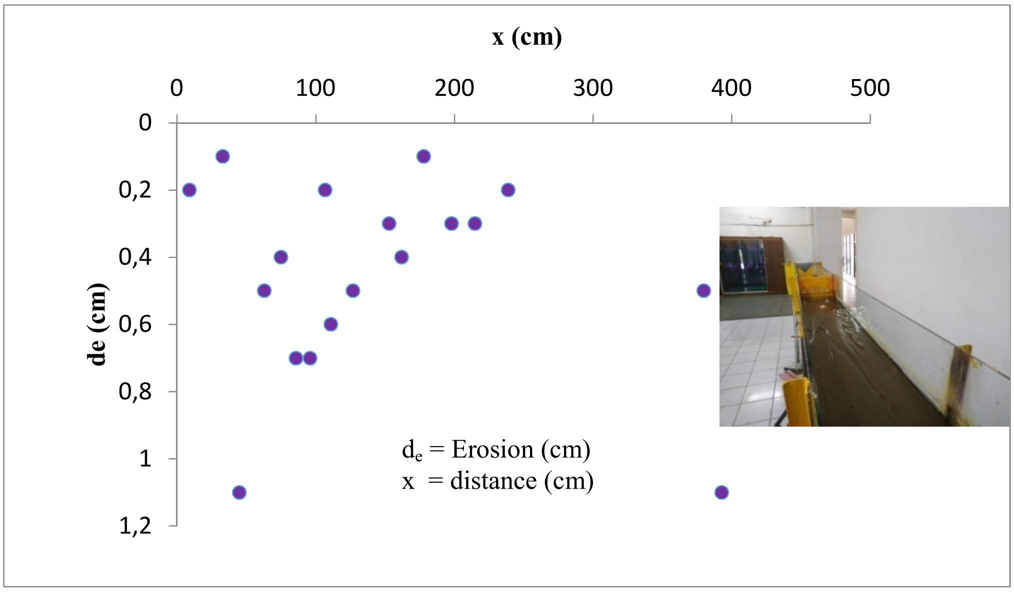

Fig. 4. Plotting The Results of the erosion depth (de) during the "running test" for 15 minutes

From Figure 4, with an experimental time of 15 minutes on the river estuary model, the erosion depth is 150 mm and then continues to decrease at a distance of almost 400 cm and then increases by 1.5 cm.

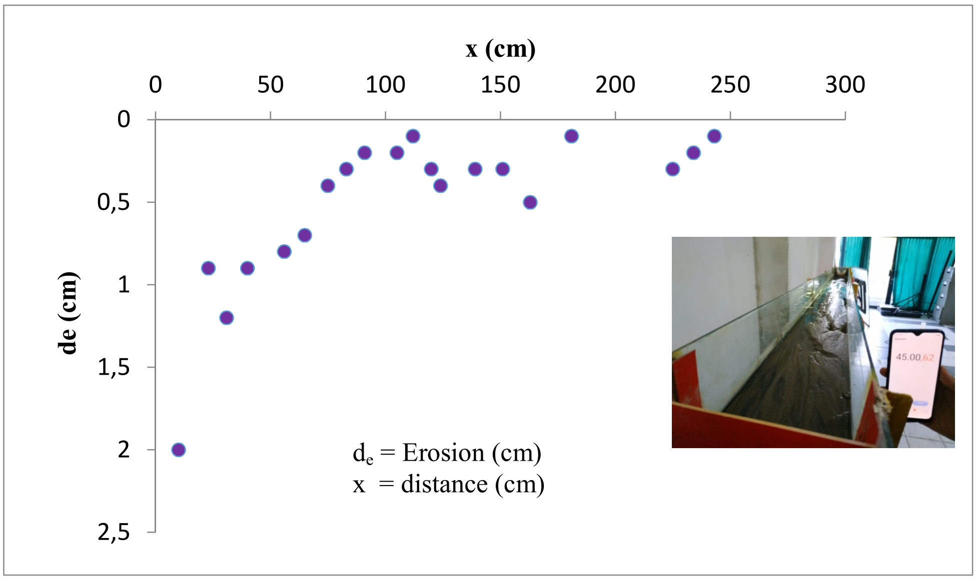

Fig. 5. Plotting The Results of the erosion depth (de) during the "running test" for 20 minutes

From Figure 5 with an experimental time of 20 minutes on the river estuary model, the erosion depth is 200 mm and then continues to decrease at a distance of 250 cm by 0.10 cm.

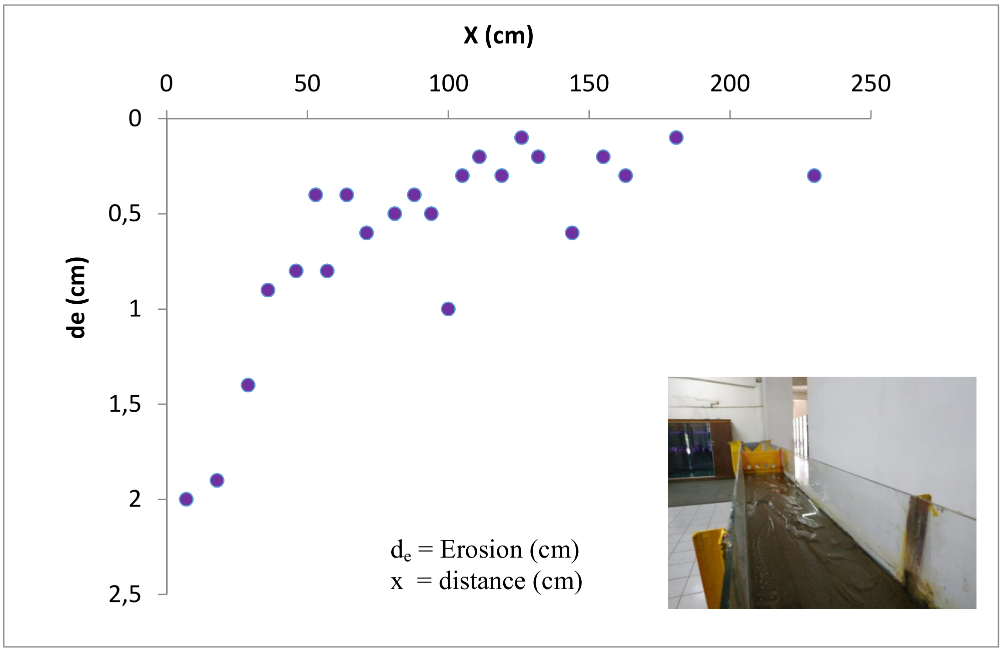

Fig. 6. Plotting The Results of the erosion depth (de) during the "running test" for 25 minutes

From Figure 6 with an experimental time of 25 minutes on the river estuary model, the erosion depth is 200 mm and then continues to decrease at a distance of 225 cm by 0.25 cm.

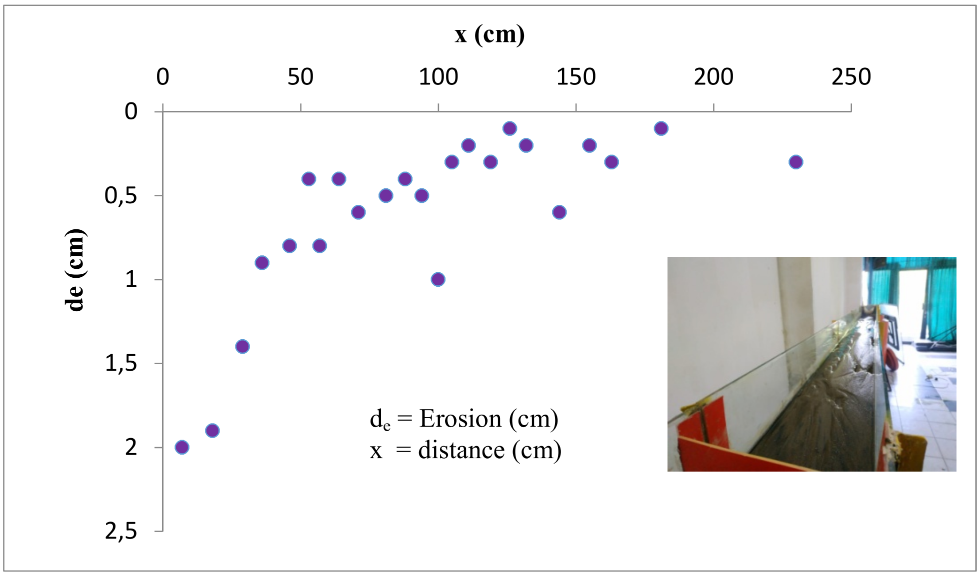

Fig. 7. Plotting The Results of the erosion depth (de) during the "running test" for 30 minutes

From Figure 7 with an experimental time of 30 minutes on the river estuary model, the erosion depth is 200 mm and then continues to decrease at a distance of 230 cm by 0.25 cm.

IV. Conclusion

The greatest depth of erosion (scour) that occurred was 200 mm at the experimental time for 20 minutes, 25 minutes and 30 minutes and at the estuary of the Buah river model. It can be said that the longer the flow time there will be scouring (erosion) at the bottom of the Buah river with the dominant factors being an increase in velocity in the river (v), grain diameter (d).

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