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Equilibrium Sedimentation in Sandy Gravel River Bend by Crib Placement Alternate

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Abstract

River equilibrium is needed to protect river buildings to avoid erosion or sedimentation that causes the building to fail to function. This study assessed the effectiveness of the river building of the crib in two different positions. This crib reduces scouring on the bend of the river at an angle with the condition of the arch of 95°, heightening the right side occur erosion on the outer side of the bend due to a strong current flow. The condition of level most severe erosion is the bottom of the river on the right side at an angle of 80°. To anticipate erosion, constructed a crib in the river arch with two alternative crib placements. Two alternative cribs constructed at two different relative angles were used to compare the effectiveness of both crib models. Based on the methods of Meyer Peter Muller's empirical formula, analysis of sedimentation in the upstream crib concluded: to scatter sediment is relatively similar by comparing the condition of both alternative positions. With both cribs' layouts, sediment moved on the distribution and concentrated on the left side of the river. Both alternative position cribs show that the position crib on an axis radian is more effective for sediment control than the position crib makes 45° angle due to the radian axis.

Keywords: crib, sandy gravel, sedimentation, river bend, river equilibrium

Introduction

River geometry change is a function of discharge, the slope of the river bed, and coefficients of the equation can be included in multiple regression analysis [4, 18, 23]. Naturally, the river would be reached an equilibrium. However, people have to try to achieve that equilibrium faster by making artificial equilibrium, for example, by constructing cribs or checking dams. Human activities upstream can also be disturbing river equilibrium; there have been changes in river geometry, erosion, and sedimentation [5]. This problem is affected by the upstream river system that is generally influenced by human activities during the last decade. [20, 21]. The factor of safety from the river was analyzed by considering the influence of alteration of river geometry that derived from the internal and external force [4, 6]. Local could be the primary cause of failure of cross river structure. It was supposed to this is a significant consideration in cross-river structure construction [11, 24]. The river's dynamics and hydraulics cause river geometry to change constantly. To learn, it needs to understand the complex interaction between discharge, sediment transport, river bed erosion, and landslide levee [18, 19]. There are arch angles f and relative angles q in the arch of the river.

A river in a state of balance that is not occurring sedimentation and erosion in the starting point, the midpoint, and the final point of the arch [14]. Sedimentation occurs on the outer side of the arch river in the first half arch, and erosion occurs on the outer side of the river after half arch passes [13, 16]. River bends play an essential role in forming river morphology in such a way that causes erosion outer bank and sediment deposition at the inner bank [12]. In experiments, sedimentation settles due to the gravity of about 32% to 59% from the earliest mass [7, 17]. In this case, anticipation erosion will be discussed in the middle segment of the Batui River in cases of erosion in the arch of the river Figure 1. Study areas located on the arch of the river with the arch angle 95° with the existing condition is occurring erosion in the right side on the outer side of the arch effect of strong currents. This condition turned out much worse for the level of erosion at the bottom of the river on the right side at a relative angle of 80°. In this case, they attempted to anticipate that erosion by installing a crib in the arch of the river.

This study compared two alternative placement cribs to minimize the risk of scours at the river arch's bottom. Two alternatives are installed at two different relative angles and used to compare the effectiveness of both crib models. Sedimentation occurring at the river bed in the upstream crib is an indicator of the effectiveness of the crib.

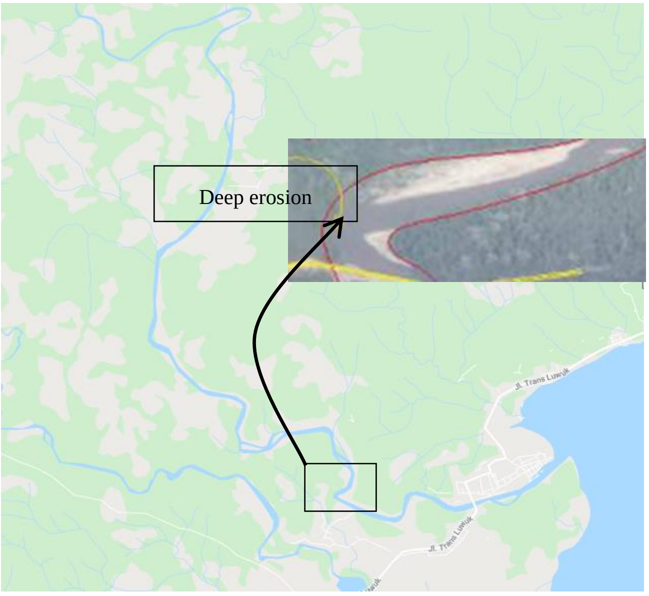


Figure. 1. *Batui River bend and erosion zone*

Previous Researches

Characteristics of erosion and sedimentation in the river bend

In the river arch, there is a rounded f corner and angles relative q to Fig.2. Sedimentation and erosion in a state of balance mean that sedimentation does not happen, and erosion on q = 0^o, f = 0,5f, and q = f. Erosion occurs on f >q > 0,5f , and sedimentation occurs on 0^o < q < 0,5f [13, 14]. If the arch of the first is continued with a rounded next, the river becomes meanders. The erosion and sedimentation characteristics on the second arch are similar to characteristics in the first arch [9] and similar if connecting with the arch next downstream. The distance between peak to peak or the valley to valley is called the length of the meander l, and while the distance between the middle line to peak meanders is called amplitude a, radius meanders arch rc and stream wide is W [14]. It increases the arch angle with the increasing expansion speed [18].

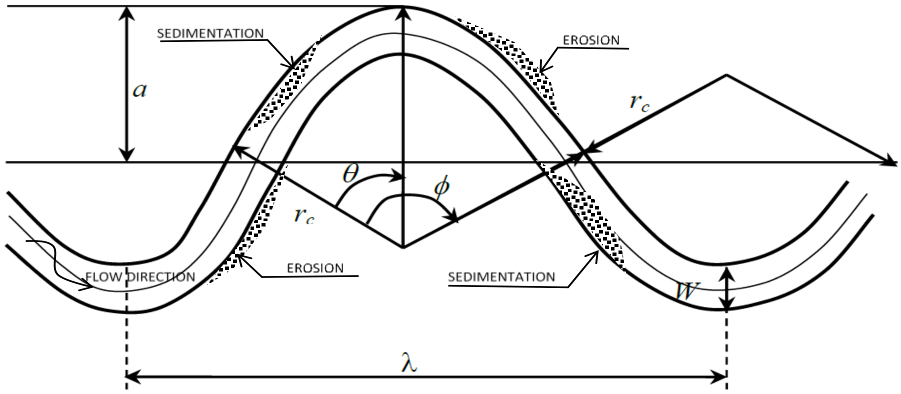


Figure. 2. *Characteristics of erosion and sedimentation in the river bend*

Interaction between morphology and flow structure

The secondary flow in the river bend is the violent influence in forming the cross-section of the river [10, 15]. It is caused by erosion in the outer bend and sedimentation in the inner bend [22, 24]. It is shown in Fig. 3 that sedimentation occurred in the inner bend and erosion in the outer bend.

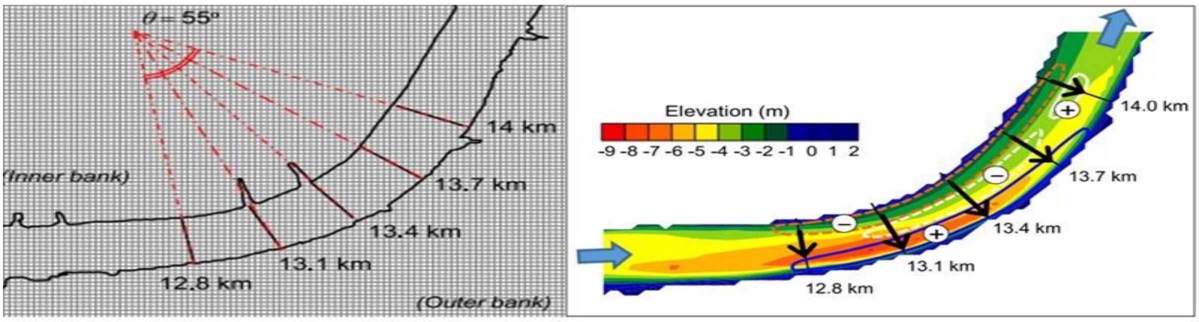


Figure. 3. *Characteristics of erosion and sedimentation meandering macro-tidal estuary on flood tide [12]*

Method

Soil and sediment sampling

Soil and sediment bed load sampling is done by drilling to a depth of 15 meters, as seen in Fig .4. A stream in a clear condition and suspended load can be ignored. Seen in Fig 4. is sediment sampling in a normal water flow in the river, the water level in the flood condition up to 3 to 4 meters. As seen in Fig.4, drilling is at the point with the inundated low water level in the river.

(b) Downstream view

Figure. 4. *Soil and sediment sampling*

The sampling result is a soil layer condition as seen in fig .5. stated Depth (meter), Ground Water Level (GWL) (meter), Sampling Point, Core recovery, Thickness (meter), Soil Description, and Standard Penetration Test. In the Depth of 0.00 - 2.50meters, the form of a sand layer, gravel, boulders, and slightly silty SPT < 50 N, in depths of 2.50 – 4.00 meters in the form of a layer of rough sand and rough a little silty gravelly with SPT 40 N, and at depth 4.00 – 15.00 meter in the form of silty sand layer, gravelly and boulder with SPT > 50 N. Screen analysis results of soil and sediment sample Fig.5. resulted material composition: gravel 28.02%, sand 67.55%, and sand/silt 4.43%.

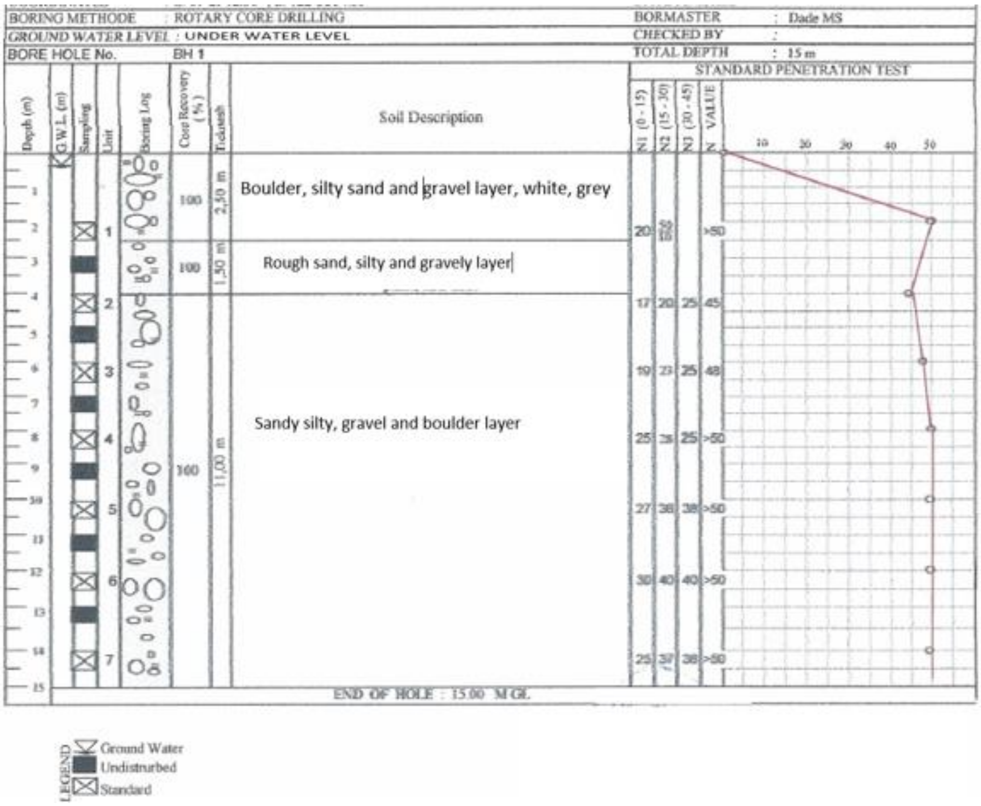
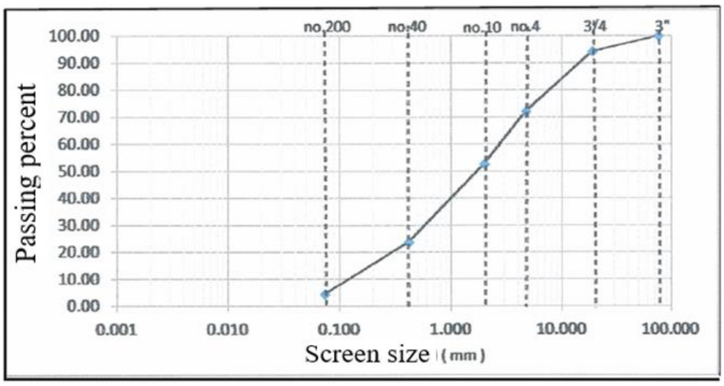


Figure. 5. *Soil and bed load sediment sampling result*



Gravel	28.02 %
Sand	67.55 %
Silt/clay	4.43 %

Figure. 6. *Soil gradation*

The geometry of the river bend

The plan form of the river in this study location is shown in Fig. 7. It found that a cliff out on the corner of the river has a precipitous slope. This slope is composed of rock hard and strong against attack erosion from the current of a stream. A current attack on that part of the river bed in the outer side bend river formed a river trough.

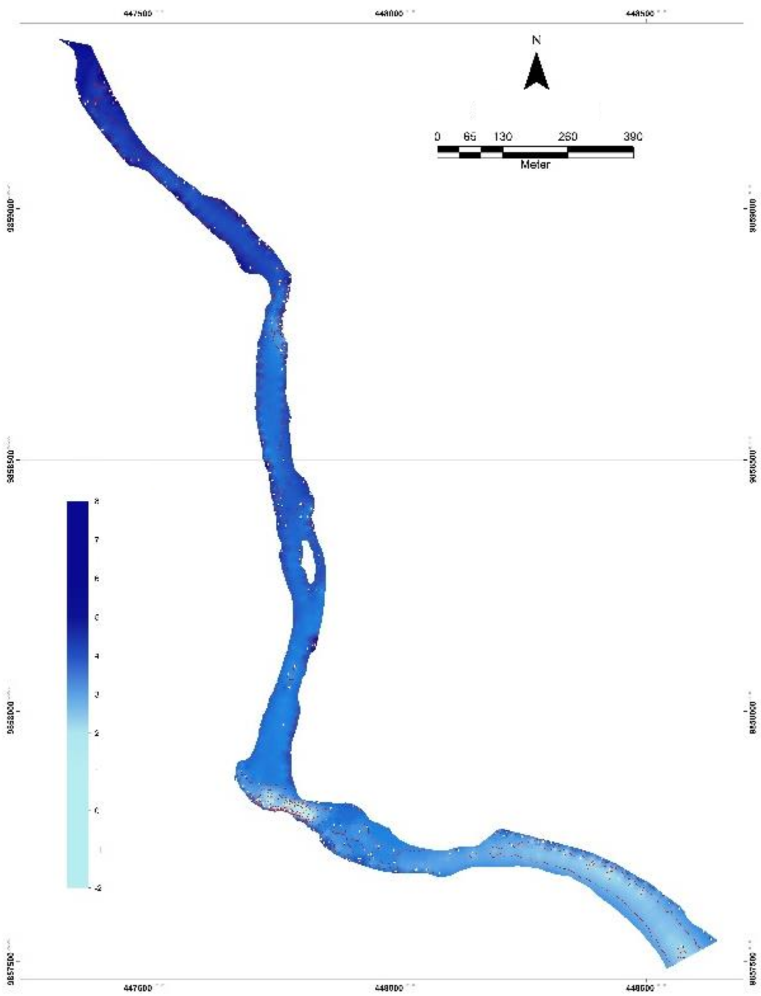


Figure. 7. *Existing river bend plan form*

Artificial equilibrium by crib and sedimentation

The form of the river bed in the existing condition of merchants is seen in Fig.7. The existing condition of the river outside the cliff is composed of hard rock not easily gradually crushed with the river bed consisting of boulders and sandy gravel. Substantial erosion occurs on a river's bottom at the cliff's outer toe [1,2]. To reduce this erosion be constructed two crib alternatives layout. Then further studied the influence of both position cribs against occurring sediment at the most vital erosion position. The further sedimentation analysis used two crib layout alternatives, the first alternative from an oblique 45° arch radius and the second alternative perfectly aligned with the radius of the arch. To predict bed-load transport sediment in the river, it was approached by three forces consideration: a. Bed stress parallel of the flow, b. Lateral stress horizontal direction, c. Vertical bed stress direction and being affected by gravity.

Sediment transport analysis based on an empirical formula by the Meyer Peter Muller methods [3,8] the influence of gravity on bed load transport be calculated as effects of the beginning of bed-load sediment movement by follows formulation:

$$Qb = C_m \left[(s-1)\, g\right]^{0,5} d_{50}^{1,5} (\mu' \tau_* - \tau_{*c})^{1,5}.$$

Where: Qb = total bed load per wide unit, τ^* = force movement parameter, $t^* = (rm^2)/(rs - r)gd_{50}$, τ^*_c = critical value of t* calculated by equation $t^*_c = (t^*)/rs - r)gd_{50}$.

Influence of motion depends on Reynold Number, $R_e = (\mu.\,d50)/v$, τ_{*c} = 0,47 if Re > 100 cm = 8, $s = \rho s/\rho$, ρs and ρ = density of sand and water, $\theta = qB/(d\sqrt{((s-1)g\,d)})$.

Table 1. *Sedimentation analysis on alternative 1 crib*

No. STA	Sedimentation Volume/month	ΔH	H before	H after
	m^3	m	m	m
STA 0+010	50.793	0.001	0.8440	0.8450
STA 0+020	64.357	0.0003	1.7680	1.7683
STA 0+030	66.085	0.0002	5.2170	5.2172
STA 0+040	73.547	0.0003	7.4610	7.4613
STA 0+050	81.563	0.0003	9.7700	9.7703
STA 0+060	89.658	0.0002	11.7660	11.7662
STA 0+075	76.57	0.0002	11.0050	11.0052
STA 0+085	82.508	0.0002	11.2890	11.2892
STA 0+095	60.901	0.0003	10.9760	10.9763
STA 0+105	69.687	0.0003	10.7700	10.7703
STA 0+115	75.832	0.0003	9.0550	9.0553
STA 0+125	84.693	0.0003	8.4680	8.4683
STA 0+140	87.323	0.0003	6.8250	6.8253
STA 0+150	89.692	0.0003	6.0650	6.0653
STA 0+160	105.552	0.0003	6.1320	6.1323
STA 0+170	74.796	0.0003	4.1390	4.1393
STA 0+180	62.987	0.0003	3.2230	3.2233
STA 0+190	58.254	0.0003	2.2770	2.2773
STA 0+200	86.362	0.0003	3.1440	3.1443

Result and discussion

Sedimentation on alternative 1 crib

The Meyer Peter Muller formulations showed sedimentation results of the influence of alternative one crib in Table 1. The form of the river bed focused on the river bend with alternative 1 crib is shown in Fig. 8

Sedimentation on alternative 2 crib

Also by the Meyer Peter Muller formulations, sedimentation results of the influence of alternative 2 crib are shown in Table 2. The form of the river bed focused on the river bend with alternative 1 crib is shown in Fig .9..

Table 2. *Sedimentation analysis on alternative 2 crib*

No. STA	Sedimentation Volume/month m^3	ΔH m	H before m	H after m
STA 0+010	55.903	0.00105	0.8440	0.8451
STA 0+020	66.123	0.00026	1.7680	1.7683
STA 0+030	59.121	0.00363	5.2170	5.2206
STA 0+040	75.337	0.00028	7.4610	7.4613
STA 0+050	95.526	0.00026	9.7700	9.7703
STA 0+060	96.044	0.00025	11.7660	11.7663
STA 0+075	85.402	0.00025	11.0050	11.0053
STA 0+085	99.736	0.00026	11.2890	11.2893
STA 0+095	97.358	0.00029	10.9760	10.9763
STA 0+105	96.723	0.00028	10.7700	10.7703
STA 0+115	90.814	0.00028	9.0550	9.0553
STA 0+125	96.367	0.00027	8.4680	8.4683
STA 0+130	96.933	0.00027	8.4680	8.4683
STA 0+140	95.809	0.00027	6.8250	6.8253
STA 0+150	95.272	0.00027	6.0650	6.0653
STA 0+160	121.915	0.00029	6.1320	6.1323
STA 0+170	78.985	0.00027	4.1390	4.1393
STA 0+180	71.131	0.00029	3.2230	3.2233
STA 0+190	61.793	0.00027	2.2770	2.2773
STA 0+200	87.231	0.00026	3.1440	3.1443

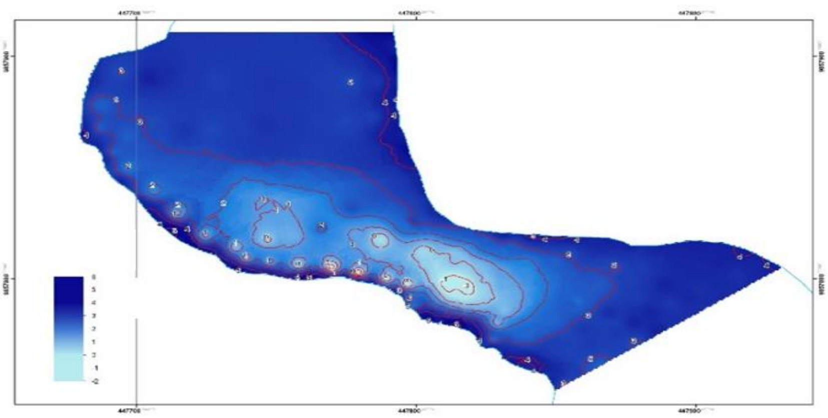


Figure. 8. *River bed formation on alternative 1 crib condition*

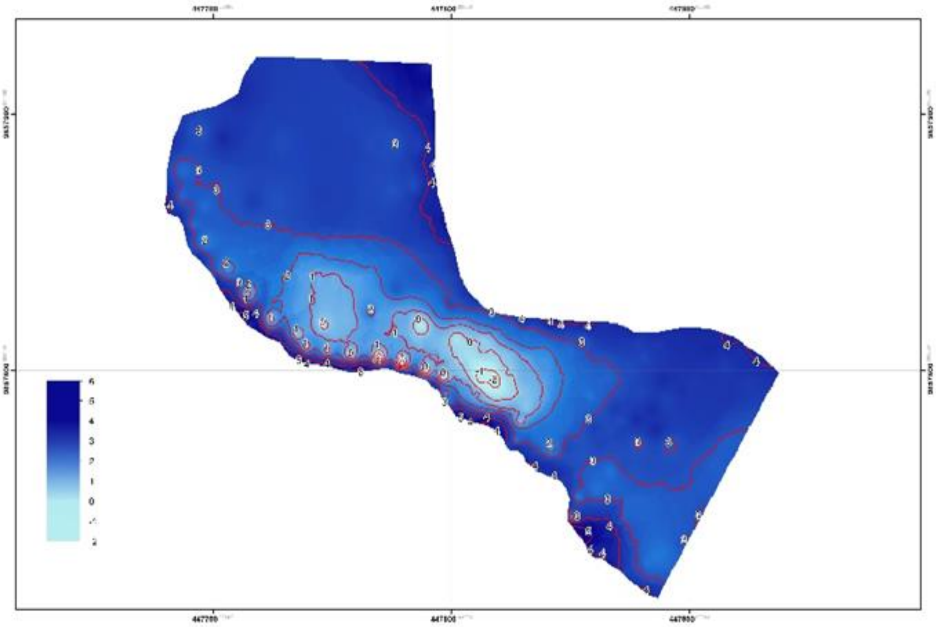


Figure. 9. *River bed formation on alternative 2 crib condition*

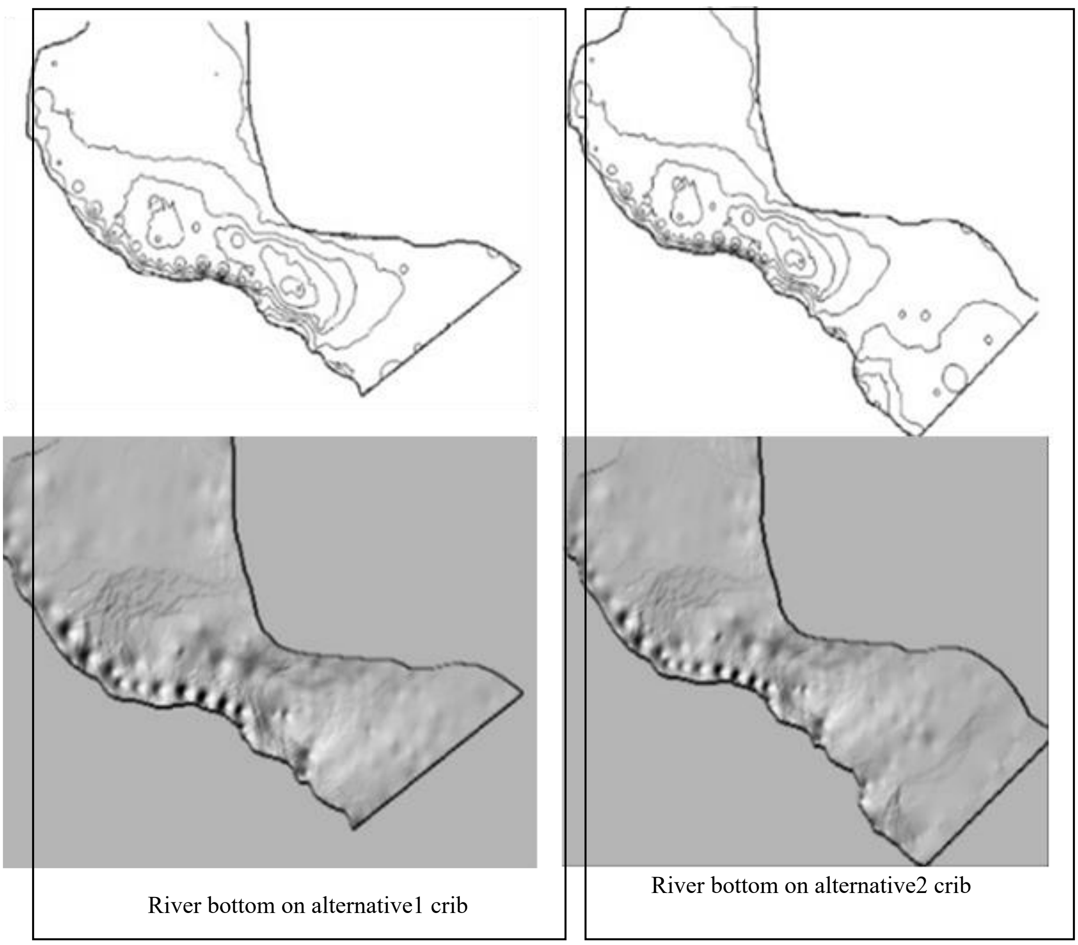


Figure. 10. *3D comparison river bed formation on alternative 1 crib and alternative 2 crib*

Comparison of sedimentation on alternative 1 crib and alternative 2 crib.

According to Table 1 and 2 the maximum volume sedimentation on an alternative 1 crib occurs on STA 0 + 160 of 105.552 m^3 per month, while in the case of an alternative 2 crib occur on STA 0+160 as 121.915 m^3 per month. Changes in elevation from maximum sedimentation on alternative 1 occur in STA 0+110 as 0.00100 meters, while in the case of alternative 2, the crib occurs on STA 0+030 as 0.00363 meters. Differences in the shape of sediment distribution between alternative 1 crib and alternative 2 crib, as seen in Fig. 10, are located in the river bed formation topography upstream of the crib. Occurring sedimentation is higher in upstream alternative 2 crib than in upstream alternative 1 crib. Following Fig .10, a significant difference was seen in sedimentation formation on the upper part of the crib. Alternative 2 crib more accommodates sediment than an alternative form of 1 crib.

Conclusions

Transport sediment analysis obtained the total sediment transport base or bed load highest on alternative 2 crib on an area 160 meters upstream position crib by 121.915 m^3 per month with a change of elevation sedimentation 0,00363 meters. as much as a result. In comparison, sediment bed transport located in the area 110 meters upstream position alternative 1 crib of 105.552 m^3 per month, the sediment elevation result of 0,00100 meters. The sediment distribution is most effective in alternative 2, where the crib is located on the radians' axis. The crib in this position produces sediment that settles every boundary spread out evenly and does not occur sedimentation only on some points. In this position average additional elevation due to the deposition of sedimentation of 0,00363 meters

Sediment scatter has a relatively stable pattern by comparing position conditions on both alternatives. With changes in the crib layout, sediment moved in a pattern of sediment scatter back concentrated on the left side of the river. Both crib alternatives' positions show that the crib located on an axis radian is more effective in sediments control than the angle 45^o from its axis radial.

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