METHOD OF FORECASTING THE DYNAMIC STABILITY OF COAST (BEACH)

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The formula is derived for determining the wash-out instability of the coastline (beach) by means of the width l of a sea, lake, water reservoir and so on.

For the case of beach wash-out by storm waves the formula makes it possible to determine the beach width l using the values of wave amplitudes ã and drift particles of average diameter $d = d_{95\%}$.

The slope value i_0 is determined for the dynamically stable beach formed on the coast line as a result of the repeated action of waves (at the time of wash-out process termination). For the coastline wash-out by waves with amplitude ã, relations are obtained for determining the width of the surface part of the beach for three ($i = i_0$; $i < i_0$ and $i > i_0$) initial value of the slope i of the underwater part of the beach.

It is known, that sea during storm creates quite a few problems to the people residing close to the beach by offshore motion of sediments and by deforming the coast thus breaking dynamic balance of the beach.

Together with other issues relating to the hydraulics of the tail water, the formula (1) which can be used for determining the stability of beaches and banks of seas, lakes, reservoirs by defining *l* width of the offshore motions of sediments (figure 1) is given in the work [1]:

$$l = 0{,}325 \frac{\tilde{a}^2}{d}, \tag{1}$$

where, *l* is width of the surface (beach) covered by water and partially dried out; $\tilde{a}$ – wave amplitude; d – average diameter ($d=d_{95\%}$) of beach forming soil granules.

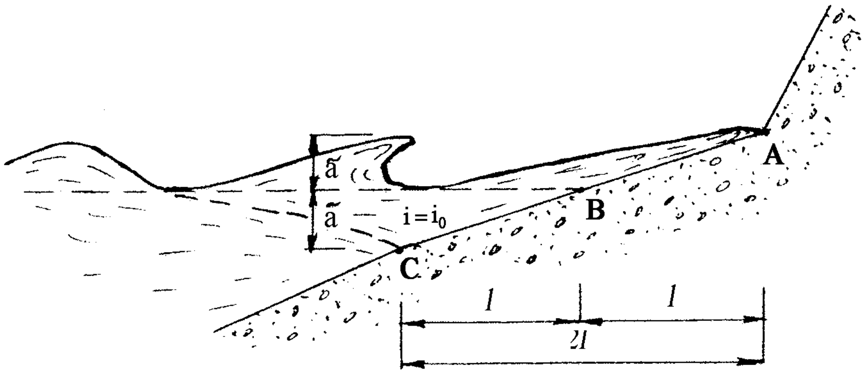

Figure 1. Diagram of offshore sediment motion of the beach having $i=i_0$ slope by the waves equaling to $\tilde{a}$ amplitude

A, B and C points are respectively the crossing points of maximum rolling of the wave at the beach line against the beach slope formed as a result of multiple effect of $\tilde{a}$ amplitude waves (at the process end) (A), free water surface in case of absence of the waves (B) and water level decrease by the wave (C).

Beach slope

$$i_0 = \frac{\tilde{a}}{l} \qquad (2)$$

It is natural that *l* value will achieve the boundary value as a result of multiple effect of the wave on the coast, i.e. the offshore sediment motion will terminate as a result of its dynamically stable i_0 beach slope.

During offshore sediment motion by storm waves, (1) allows:

a) **to determine *l* width of the offshore sediment motion when knowing the values of the wave amplitude ($\tilde{a}$ amplitude) within the coast and average diameter (d) of the granules contained in the beach forming soil (sand, gravel, stones);**

b) **by preliminary assumption of the wave amplitude within the coast and numerical values of *l* width of the beach we would wish, to determine the average diameter of the beach forming soil granules by which, in case of covering the coast, the width of the offshore sediment motion will not exceed preliminarily assumed *l* value, i.e. (1) formula allows to determine the average diameter of the granules of the soil covering the coast of the *l* width beach we would wish to form.**

The method is acceptable in case of high percentage of the clay particle content on unconsolidated friable soils of the beach having low bonding coefficient, and that is why in case of the soils with high value of the bonding module the method is acceptable at an initial calculation stage for rough approximate estimation of the above mentioned parameters (*l* width of the beach obtained by the calculation will be more than the true width).

When determining *l* width of the offshore sediment motion, the value of angle of BC underwater areas (initial slope i) of the beach before commencing the offshore sediment motion by $\tilde{a}$ amplitude waves should be taken into consideration too. Here, we might have three cases:

1) **$i=i_0$** 2) **$i<i_0$ and** 3) **$i>i_0$.**

1) When $i=i_0$, it is natural that the width of (AB) above water as well as (BC) under water areas of the offshore sediment motion at this time will equal to *l* (figure 1).

2) $i<i_0$ (figure 2) at this moment, since the width of BC under water beach area is more than the width of the respective BC' under water area of imaginary $i=i_0$ slope (BC>BC'), the energy of the wave moving towards the coast (respectively $\tilde{a}$ wave amplitude) decreases and l_1 width of the expected offshore sediment motion of EB over water beach area will be less compared to *l* width the offshore sediment motion of AB over water area formed during imaginary BC' under water area having $i=i_0$ slope ($l_1<l$).

3) $i>i_0$ (figure 3) in this case causes the formation of holes in this segment by washing off and washing out the (CB'B) under water beach segment having $\tilde{a}$ amplitude waves, which, from its side, conditions falling and washing out of A'ABB' over water beach segment. As a result of multiple effect of $\tilde{a}$ amplitude waves, i.e. at the end of the washout process, both the slope of (A'B') over water beach area and the slope of (B'C) under water area will equal to i_0 slope causing the displacement of A' and B' beach points respectively to A and B points. This means that at the process end, B'D width of (B'A) over water area washout will increase by A'A value compared to the width of B'A' over water area corresponding to the imaginary $i=i_0$ slope

$$A'A=C'C=(C'K - CK)= l - CK. \quad (3)$$

From ΔCB'K

$$CK=B'Kct\alpha= \tilde{a}\, ctg\alpha. \quad (4)$$

Here, α is the angle between the directions of B'C beach surface area before commencement of offshore sediment motion by $\tilde{a}$ amplitude waves and free water surface in case the waves are present.

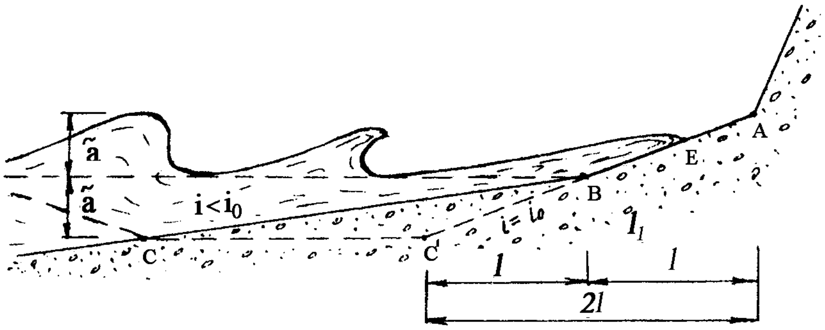

Figure 2. Diagram of the offshore sediment motion in case of BC under water area having $i<i_0$ slope by $\tilde{a}$ amplitude waves

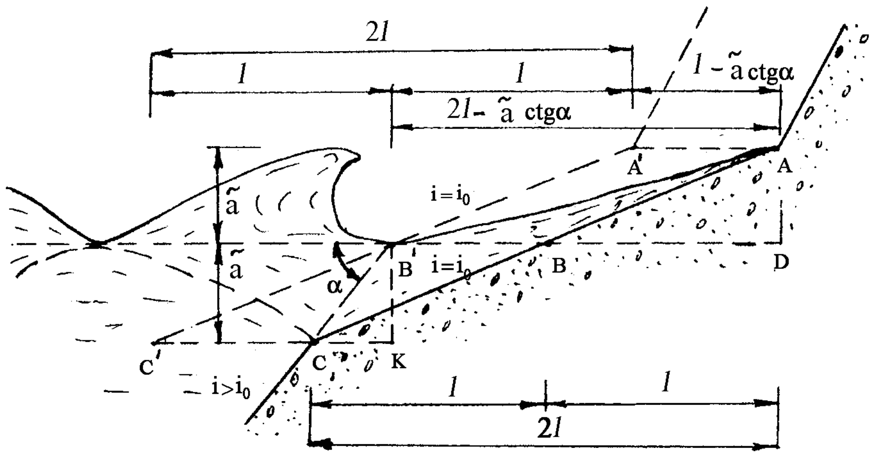

Figure 3. Diagram of the offshore sediment motion in case of B'C under water area having $i>i_0$ slope by $\tilde{a}$ amplitude waves

By inserting (4) into (3), will obtain:

$$A'A = l - \tilde{a}\, ctg\alpha \quad (5)$$

Finally, the width of the offshore sediment motion of the over water beach area at the process end will achieve

$$\mathbf{B'D} = l + \mathbf{A'A} = l + (l - \tilde{a}\ \mathrm{ctg}\alpha) = 2l - \tilde{a}\ \mathrm{ctg}\alpha \qquad (6)$$

α angle increases by increasing the numeric value of i slope, and when $\alpha \to 90^0$ ($\mathrm{ctg}\alpha \to 0$) the width of the offshore sediment motion of the over water beach area

$$\mathbf{B'D} \to 2l = 0{,}65\frac{\tilde{a}^2}{d}, \qquad (7)$$

meaning that during the offshore sediment motion by $\tilde{a}$ amplitude waves, the width of the offshore sediment motion of the over water area will never exceed $0{,}65\frac{\tilde{a}^2}{d}$.

REFERENCE

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