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To the Calculation of Storm Surges in Closed and Open Sea Water Areas

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Though a great number of works are devoted to storm surges for the purpose of their engineering calculations both in closed and open water areas, we all the same nowadays use the equation

$$\frac{dS}{dx} = \frac{kU^2}{g(H+S)} \qquad (1)$$

that was for the first time used in the survey paper "Engineering Aspects of Hurricane Surges" by K.L.Bretschneider (see the collected works [1]).

In (1) S is the height of a storm surge calculated from the static water level, U the wind velocity, x is the horizontal coordinate coinciding with the wind direction, [U+FFFD] $is the static water depth; the coefficient$ k(k≈ 3.3×10^{-6}) simultaneously takes into account the friction on the water surface (which plays a crucial role in the formation of storm surges) and on the sea bottom. As different from Bretschneider's solution (which does not satisfy the conditions of water mass preservation for closed water reservoirs) for closed and open water areas we replace the values H and S in equation (1) by the total water depth $h = H + S$. As a result we obtain the equation with separable variables

$$i_0 + \frac{dh}{dx} = \frac{kU^2}{gh}. \qquad (2)$$

Determination of a storm surge on open sea coast slopes is a relatively difficult matter because the location of the initial sea depth H_0, where the storm growth of S is assumed to be equal to zero, cannot be determined by the existing approximate solutions.

To solve (2) for a continental shelf with constant slope i_0, we introduce a new boundary condition which is fulfilled only for the coastline

$\frac{dS}{dx} = -\frac{dh}{dx}$ for x = 0 and $S = h$, (3)

and which immediately implies that on the coastline (for x = 0) the storm water surge is calculated by the formula

$$S_0 = h_0 = \frac{2kU^2}{gi_0}. \qquad (3)$$

As a result of solution of (2) with boundary condition (3) we obtain the following equation for construction of the free water surface of a storm surge both in the coast and in the sea water area

$x = \frac{kU^2}{gi_0^2} \cdot \ln\left(\left|\frac{-kU^2}{kU^2 - i_0 \cdot gh}\right|\right) + \frac{2kU^2}{gi_0^2} - \frac{h}{i_0}$. (5)

Accordingto (5), the maximal length of the inundated coast with undestroyed wave front (i.e. the location of the point where h = 0) is equal to L_e=$2kU^2/gi_0^2$. In that case, the surface wave surge crosses sea water level (S=0) at a distance$L_s = 8.39kU^2/gi_0^2$from the coastline (x= 0), i.e. this distance value is four times larger than the length of the coast inundation.

References

1. Estuary and Coastline Hydrodynamics, Ed. By A.T. Ippen, McGraw-Hill, New York, NY 1966, 744 p.