SOFTWARE PACKAGE FOR CALCULATING THE HYDRO- AND LITHODYNAMICS OF THE LITTORAL ZONE OF TIDE-FREE SEAS, LAKES, AND RESERVOIRS

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The shores of lakes, seas, and reservoirs are an invaluable national asset. Many of them possess medicinal and recreational qualities, which are conducive to the building of health spas and tourist resorts. Under the increasing anthropogenic load, and also the influence exerted by unfavorable natural factors, however, the shorelines in many countries are subject to destruction and degradation over a significant expanse. Moreover, pollution of littoral water areas makes it necessary to remove recreational structures and complexes to considerable distances from the shoreline and to greater depths. These factors lead to intensification of water-development construction, including untraditional construction, and to retention or improvement of the recreational qualities of the shorelines, and also for other economic purposes. Water-development structures (including open beaches) are complex and highly capital-intensive engineering structures. The problem of reducing the cost of water-development structures without lowering their quality and damaging the condition of the shoreline and littoral processes is therefore extremely urgent. The search for such an optimal design solution is accompanied by a large volume of engineering calculations.

The Black Sea Division of Marine Coastal-Protection Structures, All-Union Scientific-Research Institute of Transportation Construction (Central Scientific-Research Construction Institute) has developed a software package (SP) for calculating the hydro- and lithodynamic characteristics of the littoral zone of seas, lakes, and large reservoirs.

The SP makes it possible to solve the following problems:
- the introduction of initial hydrometeorological data on wind and (or) wave and surface-level regimes;
- the introduction of a digital model of the locality (the relief and elements of the situation) on a regular rectangular grid;
- calculation of wind-generated waves over the depth of the water or at an intermediate depth of the pool;
- calculation of the transformation, refraction, and breaking of waves and their rolling onto the shore;
- calculation of the height of wave pileup, and the velocities of drift currents along the shoreline;
- calculation of the capacity (transport capacity) and flow rate of sediment-carrying currents along the shoreline under the action of design storms and (or) mean multiyear surge with allowance for the effect of longitudinal and shore-protection structures (solid or open walls, embankments, breakwaters, spur dikes, etc.) and drift currents;
- calculation of sediment balance in the flow along the shore;
- calculation of dynamic-equilibrium profiles and the volumes of artificial fills for open or protected beaches with an assigned service life;
- calculation of bottom and shoreline deformations in the littoral zone of the sea for design storms and (or) the mean multiyear surge over an assigned number of years with allowance for the effect of water-development structures;
- calculation of the extent to which transverse grooves drift;
- calculation of the interaction between waves and permeable shore-protection structures (solid or open walls, moored grillages, and their posterior couplings). The height of ascent of the level near the structures, the horizontal and vertical loads on them, and the reflectances and passages of waves through the structures, including the height of the waves on the water areas being protected (in harbors);
- optimization of the structural dimensions of permeable structures in terms of assigned parameters (height of passing wave or height of ascent of water level at the structure);
- calculation of wave loads and effects on underwater breakwaters, the components of spur dikes, and solid walls with a vertical or curvilinear surface and with or without the backfilling of soil on the shore side;

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calculation of wave loads on the stabilization of shore slopes in the form of slabs, and filling (placement) with stone or shaped blocks, including determination of the mass of the limiting equilibrium of the components of slope stabilization; calculation of wake-induced loads on the stabilization of river banks or channels; and, calculation of ice loads on all types of water-development structures.

The calculations were performed both within the framework of standard documents \[1, 2\], and also in accordance with specially developed methods \[3, 4, 5\].

A graphical representation of the following information can be produced in running the software package (with a subsequent hard-copy output of the screen);

- plotting of the mean-multiyear wind rose;
- plotting of the mean-multiyear surge rose;
- plotting of bathymetric plans of the water areas under investigation on different scales and with an assigned interval of the relief section with isobaths;
- plotting of refraction plans for waves from all wave-critical directions;
- plotting of plans of the deformation relief of the bottom and shore (for example, for a storm surge) on a background of the initial relief;
- plotting of bottom profiles (existing or projected) in accordance with sizes across the digital locality model;
- plotting of the storm-deformed shoreline on a background of its initial position in the presence of transverse beach-retaining structures and bottom-deepened cuts, or in the absence of any structures (open beaches); and,
- plotting of graphs showing the capacity and flow rates of the stream of sediments along the shore [mean-multiyear and (or) storm for all design storms]. Deformations of the bottom relief of the bayshore at the "Raduga" Boarding Pier on the southeast coast of Crimea under the design storm are presented as examples of the calculation (Fig. 1): east/southeast. Results of calculation of the dynamics of an artificial pebble beach protected by a system of spur dikes are presented for a segment of the shore at the "Skif" Boarding Pier in the city of Alushta (Fig. 2).

The software consists of four sections: