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Steady, two-dimensional flow of ground water to a trench

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ABSTRACT

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The problem under consideration is a steady ground water inflow to a single trench which drains a water-bearing layer of infinite extent. The equipotential corresponding to the trench outline is determined from the solution for extremum problems. The isoperimetric constraints selected for solution of these problems include cross-sectional area, seepage flow rate and size of a region with a guaranteed head loss. The equations for the required extremals and variable functions are written explicitly in terms of the solution for the Dirichlet problem.

INTRODUCTION

As a rule, the design of a hydraulic structure (such as a channel, apron or drain) is calculated for a specific shape, and the investigation incorporates the seepage characteristics (including hydraulic head, stream function and velocity). Having defined these characteristics, as well as the integral values (such as flow rate, volume of a wetted soil and amount of impurities entering the aquifer), a conclusion is drawn on the feasibility of the structure from the engineering or ecological point of view. If some requirements are not satisfied (for example, seepage losses from the channel are too high, or the level of decline of the water table by drainage is too low), some change in the shape or dimensions of the structure or its arrangement in the aquifer is required, and the design is revised.

It is possible to take another, structural approach, based on the concept that, a priori, it is not the structure specified, but a set of requirements which the seepage field should satisfy. Then, according to these requirements, a shape for the structure is defined. This approach is based on the theory of optimization and is widely used in various fields of mathematical physics (Haslinger and Neittaanmäki, 1988). Let us take two classical examples from the theory of elasticity and aeromechanics. What should be the shape of a bar