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Generalization of the Carrier-Greenspan approach for nonlinear wave runup in bays of arbitrary cross-section

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In this work we present a rigorous analytical solution of nonlinear shallow water theory for wave runup in inclined channels of arbitrary cross-section, which generalizes previous studies for wave runup on a plane beach and in channels of parabolic cross-section. The solution is found using a hodograph transformation, which generalizes the well-known Carrier-Greenspan transformation for wave runup on a plane beach. As a result, nonlinear shallow water equations are reduced to the linear wave equation for an auxiliary function and all physical variables can be found in terms of this function by algebraic expressions. In the special case of a U-shaped channel it is a spherically symmetric wave equation in space, whose dimension is defined by the channel cross-section and can be fractional. As an example, runup of sinusoidal wave on a beach is considered for channels of different cross-sections and influence of the cross-section on wave runup characteristics is studied.