The Petrov–Galerkin finite-element method is used to solve the unified Kadomtsev–Petviashvili equation (Chen and Liu, 1995). Numerical experiments have been focused on studying the effect of slowly varying topography on the propagation of surface solitary waves in a stationary channel and Kelvin solitary waves in a rotating channel. We find that in the absence of rotation, an oblique incident solitary wave propagating over a three-dimensional shelf in a straight wide channel will eventually develop into a series of uniform straight-crested solitary waves, together with a train of small oscillatory waves moving upstream. With proper phase shifts, the shapes of these final two-dimensional solitary waves coincide with those of solitary waves emerging from a corresponding normal incident solitary wave propagating over the corresponding two-dimensional shelf. In a two-layered rotating channel, the variation of topography does not have much effect on the propagation of a Kelvin solitary wave of depression, whereas it can have a significant influence on the propagation of a Kelvin solitary wave of elevation. Explanations for these numerical findings are given.