# TWO DIMENSIONAL NUMERICAL SIMULATION OF RIVERBED VARIATION IN IN MOUNTAINOUS RIVER BEND

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## ABSTRACT

Flow of the mountainous river is a complex phenomenon, which is characterized by steep slopes, water depths in the order of the height of the roughness elements, a wide range of bed material sizes, and distinct bed structures. The mountainous river may be defined as a stream in a mountain area with steep channel slopes ranging from 0.1 to 10% or more. Our current knowledge of flow of the mountainous river was slowly improving and making certain progress. However, it was remaining a challenge due to the lack of understanding of the interrelationship between flow and sediment. The bed material of the mountainous rivers is often a bed mixture of sands, gravels, cobbles, and boulders up to 1 or 2m in diameter. Sediment transport capacities during flood events can reach very high values and bed load may contains a high portion of gravel, cobbles and boulders. Thus, sediment transport dynamics in these channels may substantially differ from those in lowgradient channels. In the past, most numerical models have been developed in lower gradient channels. In the recent decades, more and more flow and sediment transport models have been developed for steep channels. Prediction of flow in the mountainous river may depend on most common equations not considering the morphological peculiarities of the research areas in conjunction with their limited capability. Bed load equations developed by several authors for low slope rivers are rarely applicable to steep river in mountain areas.

Researches on the flow and sediment transport problems in open channels with steep slope is usually very difficult. This is a complicated subject due to abrupt changes in bed topography, rapid variations in flow regime as well as large roughness elements, etc. In this study, numerical model was developed to calculate flow and bed level variation in open channels with steep slopes where the maximum bed material size is in the range of cobbles. Governing equations are discretized using the finite difference method on staggered grid. The model system consists of a flow module, a sediment transport module and a bed level variation module. The flow module is based on the mass and momentum conservation equations in two-dimensional Cartesian coordinates. The bed level variation module is based on the sediment continuity equation and gain material distribution is applied for individual size fractions. The sediment transport module comprises empirical bed load formulas. Numerous equations have been developed and widely used to predict bed-load transport rate. Unfortunately, the predicted bed load transport rate often differs by orders of magnitude, as well as giving little confidence in the computation results. In addition, local conditions of specific application areas are often very different compared with laboratory conditions where bed-load formulae were constructed. For this reason, in this research an empirical formula for calculating bed load transport rate was developed. Flow and sediment transport modules are simulated in a decoupled manner.

Numerical model has been tested by simulating the flow situation in the experimental channel and simulating a flood event in open channel bend. The first experimental case concerns the aggradation in an experimental channel, and the second case concerns the bed level variation during a flood event in the Asungjun section of the Yangyang Namdae mountainous-river with complex geometry. The simulation results are compared with data from experimental and field measurements. Detailed comparison results of the water surface elevation shows generally good agreement. For the bed level variation simulation results are quite consistent with measured data.

**Key words:** Open channels, steep slope, sediment transport, bed level variation, empirical formula