# Collapse Settlement in Rockfill Material

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**Abstract**

The analysis of submergence in rockfill dams and road embankments is of great importance because of collapse settlement that occurs during first impounding. Here collapse settlement due to saturation of a rockfill media in a column and an embankment are numerically investigated. For simulation of collapse settlement in these separate geometries, 3 models have been used in finite difference code, FLAC including Elastic, Mohr Coulomb as well as modified Soil Hardening-Softening Model which has been modified by application of soil hardening behavior relationship. Nonetheless the main feature of the simulation is introduction of a collapse coefficient. Horizontal and vertical displacements at the slope of embankment are depicted to explain the nature of displacements due to impounding. To assess influence of different values of collapse coefficient, collapse analyses are carried out with a variety of collapse coefficient values.

**Keywords: Collapse settlement, Saturation, Rockfill, Embankment, Numerical modeling.**

## 1. INTRODUCTION

Observation collected in the upstream sell of rockfill dams show a slow accumulation of deformation over many decades, and a collapse is noticed when these sells are submerged. A collapse can also be observed on downstream shells in the case of heavy rain [1]. Collapse phenomenon in the upstream rockfill on first filling cause increase of settlement of the rockfill relative to the core. The deformation at the Cherry Valley dam is an instance of this type deformation where the settlement of upstream rockfill was more than four times that of central core and longitudinal cracks on the crest was observed at the upstream core-rockfill interface [2].

The extent of collapse settlement depends on the quality of the rockfill material and its compaction. With increasing use of poor grade rockfills, significant settlement due to this factor is becoming more common which can cause instability in body of dam, damage to rigid structures on dam crest and loss of freeboard [3]. There is a remarkable complexity in characterizing these fills due to their inelastic, nonlinear, and highly stress dependent behavior. Also, great difficulties are encountered in performing significant laboratory tests on such material. In practice several relations permit a fairly accurate representation of some of features of rockfill material behavior. A satisfactory technique for its prediction is clearly important. Nobari and Duncan [4] pioneered the modeling of collapse settlement. They developed a technique closely tied to the hyperbolic model of Duncan and Chang [5] which made direct use of triaxial test results. Its essential features are described in Chapter 12 of [6]. Soriano and Sanchez [7] presented a rigorous and complete review of the methods used worldwide to reproduce the deformations of upstream shells of rockfill dams with an earth core. After evaluating different alternatives they adopted the Nobari and Duncan [4] methodology to reproduce wetting effects.

Kovacevic [8] presented a comparison of finite element predictions with the observed behavior of Winscar rockfill dam during construction and reservoir impounding. He used hardening/softening elasto-plastic model of Lade's type. The comparison indicated that numerical results were in reasonable agreement with the field data. Hunter [9] numerically investigated different aspects of collapse settlement in rockfill and earthfill dams and concluded that deformation field of embankments will disturb due to water load, compressibility properties of the core and downstream shoulder and the susceptibility to collapse of upstream rockfill zones.

An update version of hyperbolic wetting simulation procedure was formulated by Escuder and Andreu [7] and their methodology was applied to an embankment with 100 m height. Silvani [10] investigated the