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Static and Dynamic Analysis of Rock Slope – a Case Study

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Abstract

Two dimensional plain strain distinct element method has been used to analyze a curved slope under static and dynamic loading condition. Most vulnerable cross profile of the slope has been selected through kinematic analysis and slope mass rating specially devised for curved rock slopes. Static loading has been induced in the model to simulate conditions of the prevailing rock mass. Again dynamic loading has been performed according to the expected peak ground acceleration in the area in order to simulate the slope mass condition during earthquake. According to kinematic result and slope mass rating, the slope is more vulnerable towards 70° face direction. Static analysis results an unstable portion at the base of the slope. The whole slope is unstable under dynamic loading and is expected to threat the region with the risk of rock fall as well as failure of slope.

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1. Introduction

Failures in rock slopes are controlled by both rock material and discontinuities. In highly jointed rock mass with weak rock material, failure surface cuts through intact rock but in rock masses, with less number of joints and strong rock material, failure is controlled mainly by joint planes [1]. With the presence of joints, rock mass responses better to dynamic and static loading [2]. There are many numerical codes available to simulate dynamic loading in both continuous and jointed rock mass. Among them continuum method is well-known among geotechnical fraternity [3–5]. But despite of its astounding capability to handle any complex problem with ease and without any previous assumptions, this method lacks its compatibility in representing discontinuous medium [6]. A discontinuous medium

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is defined as an assemblage of discrete blocks separated by interfaces. Though continuum methods use special techniques (e.g. joint elements in FEM), they are only applicable for less jointed rock mass where little displacement is expected [7, 8]. To deal with inherent discontinuities in the rock mass and possible rupture in the intact rock, discontinuum methods prove to be best till date. Discontinuum methods are based on dividing rigid and/or deformable blocks by deformable interfaces. Among other discontinuum methods, distinct element method has an advantage of adopting both rigid and deformable blocks along with deformable contacts [9]. This method being explicit, directly solves the equations of motion by time marching scheme [10].

This paper represents an analysis of a jointed curved slope along the treacherous road of Himalaya hills. The slope is located in the Jeori area along National Highway (NH) 22, Himachal Pradesh, India. To predict the rock mass condition and probable modes of failure in the slope, SMR and kinematic analysis have been performed. As the slope has a curved face, special techniques are adopted to the conventional kinematic analysis for better prediction of potential failure zones. Based on the slope mass rating (SMR) and kinematic results, a vulnerable two dimensional slope profile has been selected to simulate the static and dynamic response to loading of the slope under its self-weight. The Universal Distinct Element Code (UDEC) has been used to simulate this two dimensional rock slope problem.

2. Geological description

The rocks of the area comes under Jutogh group of rocks in the main central thrust zone (MCTZ) which belong to the higher Himalayan crystalline zone of Himachal Pradesh. The area has experienced a local detachment in Jutogh group of rocks as a result of ductile shearing and is named as Jeori dislocation. Common rock types in the area are quartz mica schist, muscovite biotite schist, biotite gneiss, augen migmatite, garnet bearing quartz mica schist which are highly truncated by joints and fractures [11]. The location under investigation consists of biotite gneiss and is intersected by three joint sets. Geological map of the area (left) and the location photograph (right) is presented in figure 1.

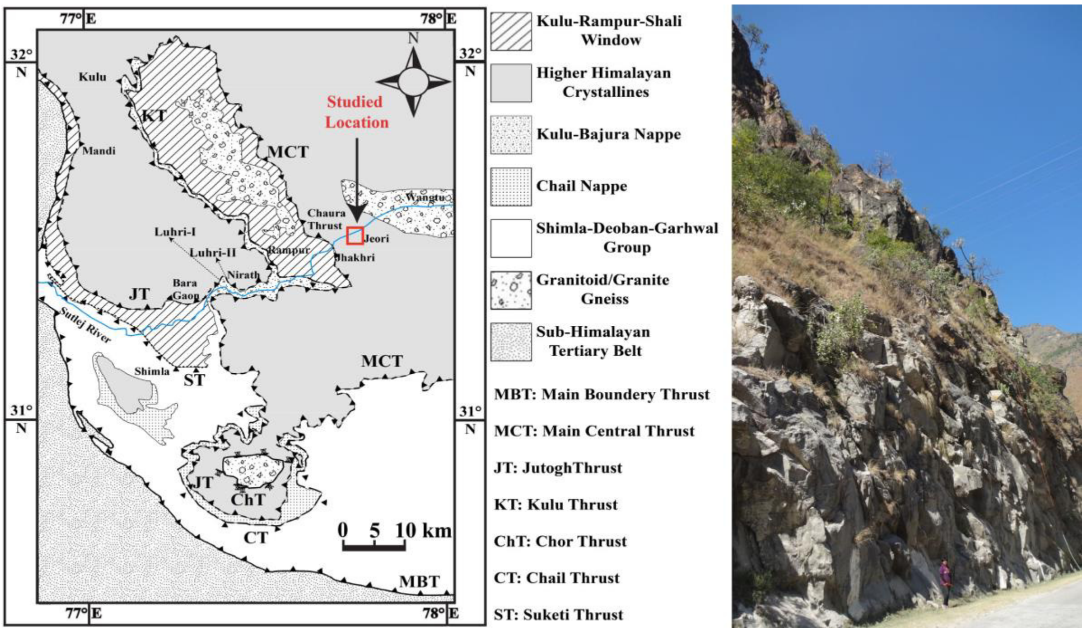

Fig. 1. Regional geological map of the area (left) (after Singh et al. [20]) and photograph of the location (right).