Chapter 6
Excavatability Assessment of Rock Masses for Geotechnical Studies

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ABSTRACT

The excavatability of rocks is of importance for the selection of suitable and cost–effective excavation methods not only in mining and quarrying but also in the construction of tunnels, subways, highways and dams. Moreover, selection of the right excavation method and equipment in mining and geotechnical projects depends on the excavatability properties of rocks. A number of different methods have been proposed to evaluate the excavatability of rocks based on their geotechnical properties, such as rock mass rating (RMR), uniaxial compressive strength (UCS), discontinuity spacing of rock masses, point load index (PLI) and seismic velocity of intact rock. The type of equipment used and the method of working also affect the excavatability of rocks. In this work, the term excavatability is considered as the ease of excavation of rock and rock masses and comprises the methods of digging, ripping, breaking and blasting for easy/very easy, moderate to difficult, soft or moderately to highly fractured rock and very difficult excavation conditions, respectively.

INTRODUCTION

Excavatability is generally defined as a relation among geotechnical, geomechanical parameters and production rate of excavation. The selection of a suitable ground rock loosening method is of significance not only in mining and quarrying, but also in the construction of tunnels, subways, highways and dams projects. The easiness and economical excavation of rock material mainly depends on the excavation type i.e. mechanical excavation or drilling and blasting. On the other hand, selection of the right excavation method and such equipment depends on the excavatability properties of rocks. Besides, the productivity

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and usability should also be optimised during the selection of the excavation method and eqipment to avoid secondary works and additional expenditure.

There are two main methods for breaking and loosening ground rocks, namely mechanical excavation and blasting method. The first one comprises digging, ripping and breaking, the latter includes blasting agents.

Digging is the process where excavators are used for removing materials from a solid surface, usually soil or sand on the surface of the earth. Diggability is a measure of the ease by which an excavator can remove the material from the solid rock mass. It depends primarily upon its intact strength, bulk density, bulking factor and natural moisture content.

Ripping is a method of fragmenting and loosening consolidated material. In other words, it is an inexpensive method of breaking up discontinuous ground or soft rock masses during excavation using a large tooth or teeth (ripper) attached to the rear of a bulldozer. Rock breakage is accomplished by the ripper lowered into the ground as the bulldozer moves forward, and, thus soil or blocks of rock masses are ripped and displaced. Rippability depends on both the physical condition (material properties) of the rock masses to be excavated and type and size of excavating machine (the weight of the bulldozer and the engine power, etc.) used. Favorable properties include planes of weakness, fractures, large grain size, brittleness, low compressive strength and weathering effects. The assessment of rippability is likely influenced by six geological factors (Bieniawski, 1989; McCormick Jr, 1983). Five elements are that of rock masses such as type, structure (bedding planes, cleavage planes, joints, fractures, consolidation and shear zones), fabric, hardness and weathering while the sixth is seismic wave velocity. The density and cementation degree of rock masses significantly affect the propagation rate of a seismic waves. Rock masses with lower wave velocities are more easily ripped.

Breaking is done with a hydraulic hammer, a percussion hammer fitted to an excavator which is typically used for rock excavation and demolishing concrete structures. It is used to break up rocks in areas where blasting is not possible due to safety or environmental issues. Hydraulic hammer can be used in most rock types, especially, soft or moderately to highly fractured rocks. Hydraulic breakers have many sizes of breaking capacity, and their selection depends on the condition and quantity of rock material.

Most rocks require blasting prior to excavation in mining and other engineering projects. The primary requirements of blasting in any operations are to produce a muck pile that is fragmented to suit operation of the excavating and hauling equipment. Blast fragmentation is affected by the physical and mechanical characteristics of the rock mass as determined by geology as well as the explosive energy, the partition of this energy, the actual amount of energy transmitted to the rock mass, the blast geometry and the detonation sequence.

Blasting contributes to the achievement in productivity and lower costs for the shovels and loaders through improved diggability and reduced oversize material in the muck pile. The reduced occurrence of oversize may also improve effectiveness of the crusher operation and reduce the cost of rehandling material in the surge pile. Digging with blasting is widely used in the excavatability of hard rocks. In urban or industrial areas, precautions are required to control damage to residences and other sensitive structures (historic buildings, landslide site, etc.) during blasting activities. In case of improper blasting, it causes economic and operational difficulties. Additionally, it can create serious safety and environmental problems, particularly when performed near inhabited areas; therefore, blasting in urban areas must often be controlled to minimize the risk of damage to the structures, and disturbance to people living and working in the vicinity. Many authors (Siskind et al. 1980; Dowding 1985; Costa et al. 1996;

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