Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 191 (2017) 419 – 425

Procedia Engineering

www.elsevier.com/locate/procedia

Symposium of the International Society for Rock Mechanics

Physico-Mechanical Behaviour of Metamorphic Rocks in Rohtang Tunnel, Himachal Pradesh, India

Tarun Singh*, Ashwani Jain, K.S. Rao

Department of Civil Engineering, Indian Institute of Technology Delhi, Hauz Khaz, New Delhi 110016, India

Abstract

The design of underground structures such as road tunnels, railways tunnels, hydro tunnels etc. depends on the data gathered through the physical and mechanical parameters of rocks. These geotechnical parameters of rock play a significant role in the design, safety, stability and maintenance of underground structures. The rocks, when subjected to heterogeneous in-situ stress-fields created by overburden, tectonic and gravitational stresses, which is locally complicated by water pressure and stresses, persuade due to excavations. The physical and mechanical parameters play very important role in a precise forecast of rock behaviour under such inconsistent conditions. The mechanical properties of rocks change with density, porosity, variation of mineral assemblage, grain size, texture and effective pressures acting on them. Changes in physico-mechanical properties in metamorphic rocks lead to corresponding variations in failure pattern.

A comprehensive study has been undertaken using three varieties of rocks obtained from the vicinity of Rohtang Tunnel in the Himalayan region. Attention has been paid to their petrographic and petrofabric analysis through scanning electron microscope (SEM) and thin sections, and physical and geotechnical properties. Various correlations between porosity, density, resistivity, sonic wave velocity in dry and saturated specimens of phyllitic and gneissic rock have been studied. Various relations have been produced between mineral compositions, porosity and density of rocks with the help of SEM and physical properties. Strength and deformation behaviour of the rocks under uniaxial compression, brazilian tension and oblique shear, in both dry and saturated states are also defined and compared with various properties. This paper highlights various relations analysed in conjunction with data on the physical and mechanical properties of metamorphic rocks.

Peer-review under responsibility of the organizing committee of EUROCK 2017

Keywords: physical properties; phyllite; SEM; UCS; mechanical properties; cohesion; modulus of elasticity; brazilian tensile strength

* Corresponding author. Tel.: +91-956-079-2368.
E-mail address: tarun.iitd@outlook.com

Peer-review under responsibility of the organizing committee of EUROCK 2017
doi:10.1016/j.proeng.2017.05.199

1. Introduction

The construction of 8.8 km long two-lane bi-directional Rohtang highway tunnel above 3000 m from MSL across Rohtang Pass near Manali in Kullu district is of strategic importance from the defence point of view as it will provide all weather connectivity between Manali and Keylong, the head quarter of Lahul-Spiti district. A comprehensive study has been undertaken using three varieties of rocks namely phyllitic quartzite (PQ), quartzitic phyllite (QP) and Migmatic gneiss (MG) obtained from the study area (south portal, Rohtang tunnel) in the Himalayan region.

The physico-mechanical behaviour of rocks depends on the intrinsic properties such as mineralogical composition, texture and porosity [1]. The petrographic and petrofabric analysis with the help of SEM and thin sections have been conducted to identify rock texture and micropores. In general, the physico- mechanical properties of jointed rock masses are important for performance prediction and the design of engineering structures built on and in rock masses [2, 3, 4]. Therefore, a detailed physico-mechanical assessment of these three rocks types is warranted. Variation of strength and deformation behaviour has also been considered in correlations to porosity, density, resistivity and sonic wave velocity. Natural hazards like flash floods and cloudbursts are frequent in Rohtang area [5, 6], thus all tests are conducted under both dry and saturated conditions.

2. Lithology of the area and sample collection

The surface geology reveals that the rock types constituting the tunnel lithounits from south portal comprises of uniformly dipping alternate sequence of quartzitic schist, intermixing of quartzitic phyllite/phyllitic quartzite and phyllite whereas the north portal starts with a sequence of biotite mica schist and migmatic gneiss. In general, the average trend of dip direction is 220° and plunge of foliation of these rocks is 350° along with three dominant joints planes and one random joint plane. The phyllitic quartzite and quartzitic phyllite rock samples were collected from the south portal side and migmatic gneiss samples had been collected from the north portal slope near the tunnel.

Phyllitic quartzite: This rock comprises of sub-angular to sub-rounded, hard, dark grey crystals of quartz and laths of biotite with minor iron minerals such as sericite, tourmaline etc. It shows equigranular in texture and quartz grains are welded together.

Quartzitic phyllite: This rock shows equigranular texture and is essentially composed of biotite, quartz and muscovite minerals. The laths of mica are also associated with crystals of dark grey quartz. Schistosity is well developed and occasional veins of quartz are common. The rock is soft as compared to phyllitic quartzite.

Migmatic gneiss: This rock comprises of sub-angular to sub-rounded coarse grains crystals of light-colored quartz and feldspar with dark-colored amphibole and biotite rich material generating a gneissose structure. The strength of rock is less in comparison to phyllites.

3. Experimental setup

To determine the physico-mechanical behavior of the rocks, various tests have been conducted following Bureau of Indian Standards (BIS) and International Society for Rock Mechanics (ISRM) standards on cylindrical rock specimens drilled using NX diamond core drill bit. These tests have been relegated under following major categories: I). Petrographic analysis to determine the mineral composition and fabric of rock, which includes thin section and scanning electron microscope tests. II). Physical properties to determine density, porosity, saturation, durability etc. and III). Mechanical properties to determine geotechnical parameters. The details of these are in Table 1.