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Geotechnical analysis and landslide susceptibility of overburden slope material in the Jammu and Kashmir, Western Himalaya

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ABSTRACT

This study examines the geotechnical properties of slope overburden material from Banihal to Ramban road section of National Highway-44 (NH44), Jammu and Kashmir, Western Himalaya. This region consists of Early Palaeozoic rock formations and is prone to mass wasting. Extensive development activities have exacerbated slope instability in this area. For geotechnical analysis, 40 undisturbed soil samples (USS) were collected and assessed for various parameters. Average values indicate moderate natural moisture content (11.6%), liquid limit (32%), plastic limit (24%), and plasticity index (7%), bulk density (1.6 g/cm³), dry density (1.4 g/cm³), cohesion (0.25 kg/cm²), internal friction angle (38°), void ratio (0.8), porosity (0.44%), and specific gravity (2.5%). The observed geotechnical results suggest moderate bearing capacity of the studied slopes, but increased landslide risk due to low cohesion in high moisture conditions. Therefore, these results may act as a policy document, aiding in land-use planning and identifying suitable sites for engineering structures.

1. Introduction

In mountainous regions, slope instabilities are frequent geological hazards. The slope stability assessment takes into account a variety of factors, including topography, material characteristics, geological information, slope geometry, groundwater conditions, alteration of materials by faulting, jointing, rainfall, and earthquake activity etc. (Song and Cui, 2016; Ehrlich et al., 2018; Soralump et al., 2021; Hussen et al., 2024). The stability of slopes composed of unconsolidated deposits is a critical concern for infrastructure development (Ehrlich et al., 2018; Komadja et al., 2021; Paul et al., 2025a, 2025b). Also, various geotechnical properties of soils influence the stability of civil engineering structures (Fattah, 2003; Zhao et al., 2013; Roy and Bhalla, 2017), and therefore are required to be checked to be used as foundation or as construction materials (Laskar and Pal, 2012). Such geotechnical assessments at the project site are necessary for generating relevant input data on foundations for design and construction of proposed structures (Nwankwoala and Warmate, 2014). For the construction of complex civil engineering projects involving heavy structures, such as bridges, dams, and multi-storey buildings, it is essential to have detailed exploration in order to prevent an adverse environmental impact, structural failure, and post-construction problems (Arora, 2008; Fattah et al., 2012; Ngah and Nwankwoala, 2013; Nwankwoala and Amadi, 2013; Youdeowei and Nwankwoala, 2013; Oghenero et al., 2014).

Overburden – a slope covering material, generally referring to the unconsolidated materials including soil, loose rock fragments, and other surficial deposits, that cover/overlay bedrock or a valuable geological resource (Bates et al., 1987). In mining, "overburden" is broadly used to describe the soil and rock that must be removed to access certain ore deposits. While in geotechnical engineering, it can refer to the soil and other materials overlying a specific geological feature or a construction site. In nature, the occurrence and distribution of soil vary from location to location. The type of soil depends on the rock type, its mineral constituents, and the climatic regime of the area. Soils are used as construction materials, or the civil engineering structures are founded on the surface of the earth. For any civil engineering structure, infor-

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