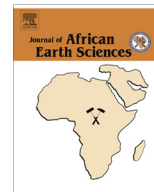




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Geo-engineering evaluation of Termaber basalt rock mass for crushed stone aggregate and building stone from Central Ethiopia

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ABSTRACT

The geology of the central part of Ethiopia exhibits a variety of rock types that can potentially be developed for construction stone production, of which the most wide spread and important one is the Termaber basalt. Even though some preliminary work is done on these rocks towards construction material application, it remains largely that this resource is untouched and needs further scientific characterization for the use in large scale industrial application. Basaltic rocks have been widely used in many parts of the world as concrete aggregate and dimension stone for various civil structures. The present research study was carried out for Geo-engineering evaluation of Termaber basalt rock mass for crushed stone aggregate and building stone from Central Ethiopia (around Debre Birhan).

The main objective of the present research study was to assess the general suitability of the Termaber basalt to be used as coarse aggregate for concrete mix and/or to utilize it as cut stone at industrial level. Only choice made with full knowledge of the basic characteristics of the material, of its performance and durability against the foreseen solicitations will ensure the necessary quality of the stone work and thereby a possibility to reach its intended service life.

In order to meet out the objective of the present study, data from both field and laboratory were collected and analyzed. The field data included geological investigations based on different methods and sample collection while the laboratory work included, uniaxial compressive strength, ultrasonic pulse velocity, dynamic elasticity modulus, bulk density, water absorption, specific gravity, open porosity, aggregate impact value, petrographic examination and XRF, aggregate crushing value, Los Angeles abrasion value, sodium sulfate soundness, X-ray diffraction and alkali silica reactivity tests. The field and laboratory data were compiled and compared together to reveal the engineering performance of the rock mass in terms of cut stone and coarse aggregates. The basaltic rock shows a variety of textural and mineralogical characteristics which could affect their physical and mechanical properties as well as their use as construction material. The compressive strength of the basaltic rock ranges from 130 MPa to 350 MPa, ultrasonic pulse velocity from 4000 m/s to 7000 m/s, open porosity from 0.33% to 3.08%, bulk density from 2.6 g/cm³ to 3.1 g/cm³, dynamic elasticity modulus from 64 GPa to 129 GPa, etc. The petrographic examination also indicated some deleterious constituents within the middle basaltic flow layers however; there are distinct flow layers which could be used as dimension stone and coarse aggregate for concrete and asphalt mix. The field investigation as well as the laboratory tests conducted indicated the high potential of the Termaber basalt formation to be used as construction material with further refining works. The study presented in this paper was carried out on basalts that are widespread in the central highland of Ethiopia and that comprise the major source of local crushed rock aggregates and building stone.

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1. Introduction

Building stones and crushed stone aggregates play a key role in creating, maintaining and enhancing the built up environment and the infrastructure on which society and our quality of life depends.

They are fundamental to the general fabric of roads and buildings. Building stones and crushed stone aggregates are essential raw materials for the construction industry.

The study area is located in the central highland of Ethiopia around a town named Debre Birhan. It stretches from Chacha to Termaber village in the north–south direction following the main highway leading from Addis Ababa to Dessie (Fig. 1). In the east–west direction, it runs from Kundi to Mendida respectively. The present study area is mostly dominated by gorges and dissected

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by west ward flowing streams and rivers of the 1st and 2nd order tributaries of the Blue Nile basin. The eastern part is marked by the western boundary of the Main Ethiopian Rift margin.

The geology of the central part of Ethiopia exhibits a variety of rock types that can potentially be utilized for construction stone production, of which the most abundant and important one is the Termaber basalt. Basaltic rocks have been widely used as crushed aggregate and building stones (ashlars, masonry stone, cobble stone and others). Basaltic rocks exhibit a variety of textural and mineralogical characteristics that may possibly control their physical and mechanical properties as well as their use as construction material. Even though some preliminary work has been done on these rocks for construction material application, still this resource needs further scientific characterization to be used in large scale industrial application.

Basaltic rocks have been widely used in various industrial applications in many parts of the world but the most widespread application is in the construction industry as crushed aggregate and building stone for various civil structures. Therefore, the current study is aimed at the physical, mechanical and chemical characterization of the Termaber basaltic rocks for its suitability as construction material.

Basaltic rocks are used extensively as engineering material throughout the world as aggregates in cement concrete, asphalt concrete, rock fill dams, railway ballast and high way base courses (Goodman, 1992). However, for each type of application, assessment of quality of aggregate is required which depends on the property of the parent rocks. Many authors addressed the issue of quality (Ramsay et al., 1974; Smith and Collis, 2001) in which rocks quality for construction material is governed by petrographical composition, texture, particle shape, porosity, among others. These properties directly affect the mechanical behavior of the rock in question. Further published laboratory test data on the property of basaltic rocks as building stone and aggregate indicate that basaltic rock aggregates improve quality and strength of concrete (Tasong et al., 1998).

On the other hand, basaltic rocks in general have higher unit weight than other rocks and, therefore, basalt aggregate has high relative density, even though, they cause segregation and therefore difficulty in pumping of concrete (Fookes, 1980; Neville, 1995).

Besides, basalt rocks also have potential from the point of view for alkali–silica reaction. Fookes (1980) gave examples of aggregate material that causes alkali–aggregate reaction which is the focus of this study. Arnould (1997) indicated that the active alkalines content of basaltic rocks is important and needs consideration before using basalts as aggregate for concrete. In addition, in some volcanic rocks, volcanic glass exists which may cause alkali–silica reaction thus may adversely affect the strength of concrete.

Basaltic rocks are widespread in the Central highland of Ethiopia (Pik et al., 1997). Basalts are in high demand now and likely to continue to be the preferred source for crushed rock aggregate in the future. The use of basalts as aggregate material and building stones is increasing from year to year in Ethiopia (USGS, 2010). The Oligocene–Miocene volcanics of Ethiopia highland of Ethiopia is mainly basic in composition and covers a wide area; however, the present study focuses only on the Miocene to late Miocene Termaber formation (Termaber basalts).

2. Materials and methods

As it has been said earlier the aim of this study is to determine characteristics of basalts of different composition and texture to be used as concrete aggregate and building stone. For this reason, geological and petrographical studies, chemical, physical and mechanical tests were performed on the basalt samples. In addition, construction is booming in Ethiopia specially construction of high apartments, condominiums, concrete asphalt and railways. Therefore, there is an urgent need for crushed rock aggregates for concrete, embankments, granular and cemented base course highways, etc. Thus, it is worth to study the characteristics of basalts to ensure quality and durability of engineering structures.

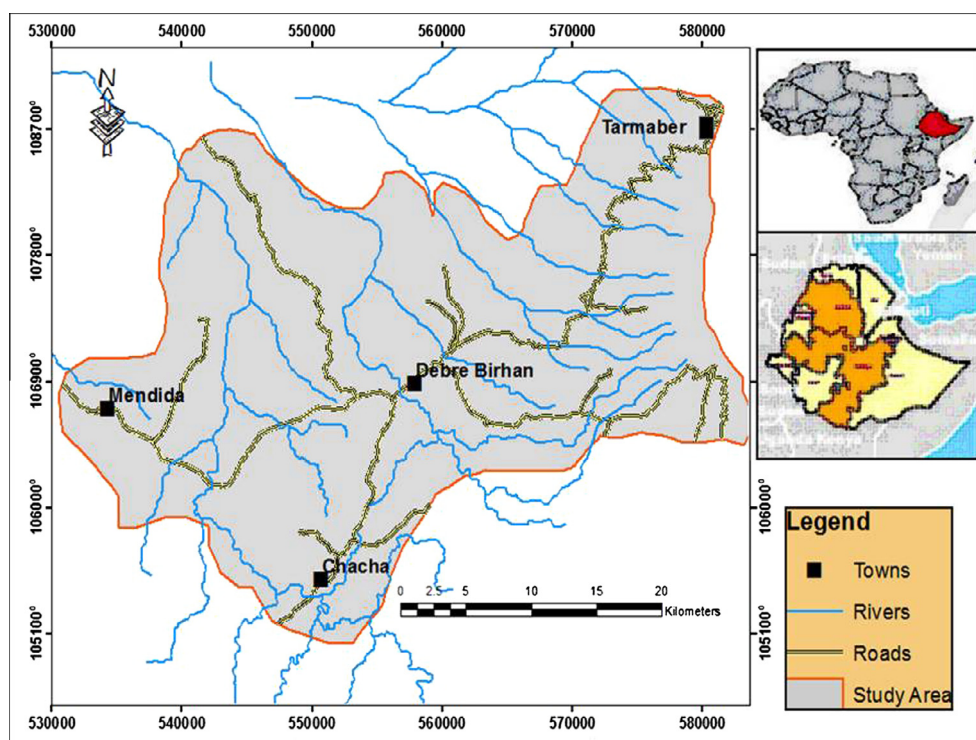


Fig. 1. Location map of the study area.

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