MAPPING VARIATION IN SOIL VOLUMETRIC SHRINKAGE USING ASTER IMAGERY

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The first stage of any major civil engineering project generally involves some form of preliminary reconnaissance study of project sites followed by detailed geotechnical investigation. Primary aim of this study is to collect data concerning physical characteristics of terrain and ground conditions in order to assess their likely influence on the overall design and performance of infrastructures or vise versa. Potential problems that could eventually affect design, performance and life time of infrastructures are best determined during pre-design and preliminary design phases when compromises can be made between structural, architectural, mechanical, and other aspects of the design without disrupting design processes. Changes during detailed design phase or during construction will probably delay construction and pose economic disadvantages. It is critical to ensure that material conditions are properly assessed in a geotechnical investigation scheme which is one of the bases for designing infrastructures. Of which is identifying expansive soils and thoroughly characterizing their geotechnical properties. Since expansive soils change their geotechnical characteristics with variations in moisture content, possible heave prediction in such soils is important. The later can be achieved through measuring geotechnical parameters of soils. There are a number of qualitative and quantitative, direct and indirect, in-situ and laboratory testing procedures available to identify and characterize expansive soils. Among which, volumetric shrinkage is a measure of decrease in volume of expansive soils upon losing moisture. The more soil testing that is done before hand, the easier it is to reduce risk in the design of infrastructure and produce economically feasible as well as environmentally compatible structures. Though, it is impractical to attempt collecting many samples over short distances and analyze them for it is costly and time consuming. Remote sensing on the other hand can give information covering a large area. It also potentially provide with a continuous representation of a site under investigation other than discrete sampling points.

This study was conducted on the new expressway route connecting Addis Ababa with Nazareth town. The sampling was part of a comprehensive investigation and testing scheme for assessing suitability and quality of subgrade material for the newly proposed road alignment. Samples were taken from shallow trial pits (of 1meter depth which is commonly the depth at which shallowly founded structures are laid) which were dug at 500 meter intervals. Deep trial pits (of up to 3.5 meter depth) were dug between 3

kilometer to 5 kilometer intervals with the purpose of determining the vertical extent of soil expansiveness.

Two ASTER level (1B) image data that are geo-referenced and geo-metrically corrected, covering the study area acquired in July 2008 was obtained from the EROS Data Center (EDC), South Dakota, U.S.A. The ASTER scenes were preprocessed including co-registration of the 30 meter spatial resolution SWIR bands with the 15 meter spatial resolution VNIR bands. Internal average relative reflectance (IAR) reflectance calibration was used to retrieve reflectance from ASTER radiance data. A spatial subset of the study area was then created from the images. Spectral angle mapper (SAM) was used to stratify the image in to built-up areas, vegetation, water bodies and soil. Non soil surfaces (built-up areas, highly vegetated places and water bodies) were masked out from further analysis. Spectral reflectance curves of soil samples were then collected from the soil class of the image. Multivariate calibration models were developed linking the image spectra with geotechnical parameter (volumetric shrinkage). A coefficient of correlation of 0.73 with root mean square error of prediction 0.072 was obtained showing much of the variation in soil expansiveness can be accounted for by ASTER image soil spectra. While bands 1 and 4 have positive loadings, bands 3, 7, 8 and 9 show negative loadings in the prediction models. Map of volumetric shrinkage, which is obtained by extrapolation of multivariate regression models show similar pattern of variation in expansivity with that of measured expansiveness.

The proposed method is a simple way of estimating soil expansiveness from multispectral remote sensing imagery (ASTER) reflectance spectra of soils which can be of prominent value in preliminary design stage of projects as well as can a basis in tailoring detailed geotechnical investigation schemes to focus on more problematic area in terms of soil expansivity.

Keywords: Expansive soils, geotechnical parameters, weighted plasticty index, ASTER, PLSR.