SHEAR BEHAVIOUR OF ARTIFICIAL SAW-TOOTH AND TENSION JOINT SAMPLES UNDER CONSTANT NORMAL LOAD

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ABSTRACT

An extensive direct shear test program of regular and irregular saw-tooth, and artificial tension joint (ATJ) samples is undertaken under constant normal load (CNL) condition to understand the evolution of shear stiffness ($k_{ss} = d\tau/du$) and dilation ($\psi = dv/du$) with respect to shear displacement (u), where τ and v are the shear stress and vertical displacement respectively. Both regular and irregular asperity samples (upper and lower blocks) are prepared using cement mortar. The angle of regular saw-tooth asperities is varied as 0^0, 10^0 and 20^0. For 10^0 and 20^0 asperity angle samples, single, double and quadruple number of asperities are prepared by changing the base length giving rise to six combinations. Irregular saw-tooth joint samples having 20^0 and 30^0 asperity angles are combined to produce five category of joints. The main motivation of preparing irregular asperities is to compare the shear behaviours if the direction of shearing is reversed. Cubical basalt block is splitted artificially by tensile force to create a joint surface and termed as Artificial Tension Joint (ATJ) samples. Then they are grouped into four categories viz. 55^0-57^0, 57^0-59^0, 59^0-61^0, 61^0-63^0 based on the values of tilt angles. The direct shear test program is carried out on both cement mortar and basalt samples of length 100 mm and width 100 mm. The heights of upper and lower blocks are 50 mm each. A total of 170 direct shear tests was carried out under CNL condition with a rate of 0.2 mm/min. Five low normal stresses satisfying the criteria of $40 < \sigma_c/\sigma_n \leq 200$ and other five high normal stresses high normal stresses belong to $1 \leq \sigma_c/\sigma_n \leq 40$ are applied for direct shear tests. Here, σ_c denotes uniaxial compressive strength of the materials.

From $\tau - u$ and $v - u$ curves, shear stiffness and dilation are estimated and found that they vary non-linearly with u. This study correlates between k_{ss} and ψ, and find that they have great significance leading up to determination of basic friction angle (ϕ_b) and subsequent development of peak dilation angle (ϕ_d). One of the main objectives of this work is to develop mathematical models of k_{ss} and ψ as a function of shear displacement for various forms of saw-tooth and ATJ joints. It is found that both k_{ss} and ψ can be approximated using two-parameter hyperbolic function with respect to u. These parameters are estimated using regression analysis using the experimental data. The shear displacement, u at which $\psi = 0$ is also found to be the point of yield shear stress (τ_y) in $\tau - u$ curve as well as the occurrence of the basic friction angle. Any subsequent development of shear stress is then the result of dilatant behaviour of the sample. The peak shear strength estimated from the proposed model is also compared with those of Barton's envelop and found to vary within a root mean square error (RMSE) of 0.58 MPa for cement mortar samples and 3.67 MPa for ATJ samples.

***Keywords*:** Saw-tooth joint, artificial tension joint, direct shear test, shear stiffness, dilation, constant normal load, regression analysis, hyperbolic function