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Experimental and Analytical Investigation of Soil Cutting.

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The objective of this work is first to determine experimentally the horizontal and vertical force components of the operative forces during soil cutting. Since previous work in soil cutting had been empirical and involved curve fitting techniques therefore the second objective is to predict these horizontal and vertical force components. In order to achieve these objectives a special apparatus was designed and fabricated for experimentation. It comprises the soil bin, the horizontal and vertical carriages, the proving rings, carriage seat frame, soil hopper, manually operated jack, and the blades. In order to reduce cost and weight of the apparatus, and also because of the limited space available, the carriages and the cutting blades were made of aluminium.

In order that this investigation can be applied to a variety of soils, Ogun river sand and beach sand were chosen because they are granular materials, but with different angles of internal friction. □□Black cotton soil was chosen because it is a cohesive soil which possesses both cohesion C and angle of internal friction □. All the soil samples were air dried, in order to have a good control to obtain repetitive results. In order to predict accurately, the horizonal and vertical operative forces in soil cutting, it is essential that some specific properties of the soil be known. The soil properties chosen for this work are cohesion, C, and angle of internal friction, □. These soil properties were determined using triaxial apparatus. Also the shear box apparatus, imposing directional horizontal failure plane was used to determine the □ values of cohesionless soils.

The cutting blades inclination B0 to the vertical was varied from O0 to 750 in increments of 150. The soil bin was filled with soil by the soil hopper, whilst the blade was inserted and pushed horizontally by manually operated 10 tonne (98.07 KN) jack, at a horizontal speed of about 0.11 cm/sec. The soil bin perspex glass enabled the tests to be observed visually. The horizontal and vertical force components operating during soil cutting was measured by standard Wykeham-Ferrance proving rings, with maximum load of 200 kgf (1962 N) and with E.L.E. dial gauge of 0.001N/division (0.0254 mm./division).

It was found that the soil properties C and used by Coulomv and Terzaghi in the expression, C = C + 6 tan were found to be true. However the soil plastically slip line configurations in soil cutting show that whereas 100% of the angle of internal friction, is mobilised for cohesive soil, typified by black cotton soil at failure, only about 80% of the angle of internal friction , is mobilised for cohesionless soils, Ogun river sand and beach sand, at failure, the mobilised values of the soils were therefore used to evaluate the horizontal and vertical components of operative forces in soil cutting. Other soil parameters like void ratio, and a new soil particle size distribution parameter index (SPI)

0.025

SPI = (Dmax - Dmin) 100

EDX/distribution dervied from grading tests, are found to be true in evaluating these horizontal and vertical components of operative forces. From these findings, empirical formulae were derived, which will be of great benefit and advantage to design engineers, who can quickly estimate the horizontal and vertical components of the operative forces during soil cutting. It was found that as blade inclination Bo and width-to-depth of cut ratio w/d, increased, the horizontal component of force in soil cutting, decreased. The horizontal force decreased by 93%, when width-to-depth of cut ratio w/d = 1, and blade inclination B0 increased from O0 to 750. The passive rankine force is less than the horizontal components of the forces in soil cutting. These forces like the Rankine force are proportional to the square of depth of cut, for vertical blades, that is, blades with inclination B = O0, the horizontal components of the forces can be evaluated by multiplying the Rankine force by constant K which is 7.025 for cohessions soils and 1.06 for cohesive soils. The present work also shows that the optimum performance of the blades occurred at an angle of inclination B = 570 for cohensionless soils. Whilst the optimum performance of the blade for cohessive soils occured at a blade inclination B = 450.

A theoretical solution of the boundary energy theory which considers the kinematics of the soil-blade system, predict most accurately the horizontal and vertical components of operative forces in soil cutting, than any other theory hitherto in use. The maximum and minimum errors in horizontal components of forces for Ogun river sand, at blade inclination B0 from zero up to the optimum performance of the blade, were 10.6% and -5% respectively. Similarly the maximum and minimum errors in horizontal components of forces at same blade inclination, for beach sand and black cotton soil, taken in pairs were

(9.2% -23.2%) and (2.8%, -0.47%) respectively. At a blade inclination of B = 300, and & = 1/2, the experimental and theoretical horizontal components of forces, taken in pairs for Ogun river sand were (130N, 126N) and error of 3%. Whilst for beach sand and black cotton soil, at the same blade inclination, the values were (100N, 101N) an error of -1% and (135N, 135N) an error of 0% respectively. Similarly experimental and theoretical vertical components of forces, taken in pairs, at blade inclination B = 300 and d = 1/2, for Ogun river sand and black cotton soil, at same blade inclination, the values were (40N, 27N) and 58N, 55N) respectively.