International Journal of Engineering Science Invention (IJESI)
ISSN (Online): 2319 – 6734, ISSN (Print): 2319 – 6726
www.ijesi.org ||Volume 7 Issue 7 Ver II || July 2018 || PP 01-05

Depth of Cuts in Cement Stabilized Sand

Noor Ul Amin[1], Zia Ul Amin[2] And Ikram Ullah[3]

Abstract: C*liffs almost vertical can be seen in clay deposits due to cohesion. This property can very well be utilized for laying services like water supply pipes, sewers etc without any external support systems. But in sand, cuts are supported externally for the above civil engineering works. When excavations have the potential to endanger lives or adjacent properties, bracing to support the soil must be designed (Nemati, 2005). Depth of cut in dry sand is zero, so for the purpose of excavation in which services pipelines or other civil engineering activity are to be carried out, then its walls are to be supported by tieback, raking system, or other systems of earth retaining. The support system generally involves the use of steel or timber or other technique. In this paper, work on the cemented sand is presented in which the laboratory tests are conducted on samples to impart slope stability quality to the sand without external support of the excavation walls. Cement is mixed at 3%, 4%, 5%, 6% and 7% of the dry weight of the silica sand and the samples were tested in the direct shear test apparatus. It is found that cohesion imparted by the cement is increased from zero of the pure sand to about 800 kPa of 7% cemented sand. The added cohesion to the sand, due to 7% cement, raises the depth of cut to about 15m according to Rankine theory of lateral earth pressure.* ***Keywords:*** *Sand, unsupprted cut, depth, cement, Rankine.*

Date of Submission: 20-06-2018 Date of acceptance: 06-07-2018

I. Introduction:

Soil is a gift from God that supports our life in every respect. One of its uses is to bury and support civil engineering services, like pipelines for water supply, sewerage systems, power cables etc. But one of the important uses is to support our civil engineering structures through its endowed property named bearing capacity. To place a structure on the soil, excavation is carried out first the walls of which may require supporting systems in the form of bracing system, rakings system, tieback system and sheet pile wall system or anchorage system (see figure 1.1).

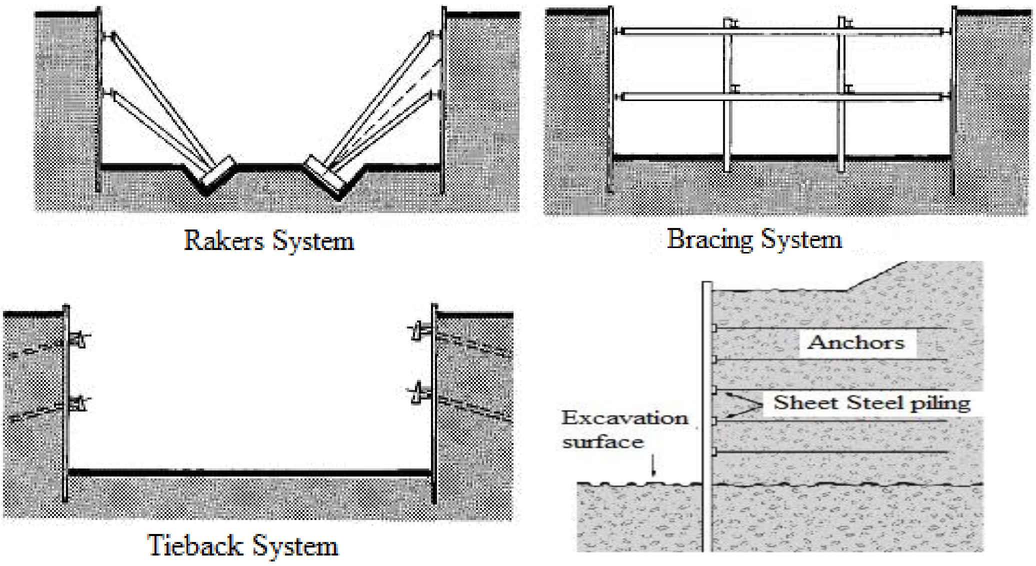

Figure 1.1: Soil excavation/ cuts wall support systems.

Some soils like soil in Hayatabad, Peshawar can support its cuts up to a depth of 6m without any external support system because of its gravel, sand and fines mix. On the other hand, sand in dry conditions cannot support its cut that can be supported through external support system which requires open space in addition to other commodities. Similarly soil on, Grand Trunk (G.T.) road Peshawar, where Bus Rapid Transit (BRT) project is under construction, can be seen to support its vertical wall up to a depth of about 5m due to cohesion. But sand cannot support its sides in cuts without support systems because of no cohesion, although it can be exhibited when moist, acquiring a temporary apparent cohesion that is lost on drying. So to get rid of above – mentioned support systems in sand, it is envisaged that cement be mixed with sand through injection or impregnation in the field to impart cohesion to it, then excavation can be made up to some depth. For this purpose, this study is undertaken to mix sand with different proportions of cement and test its samples to find the depth of unsupported cuts in the sand.

II. Theory:

In lateral earth pressure problems, Bell's formula is utilized both for the active lateral earth pressure (p_a) at depth, h, below the horizontal ground surface (equation 2.1) as well as for passive lateral earth pressure (p_p) equation (2.2) without any surcharge, (q), on horizontal ground surface.

$$p_a = K_a \gamma h - 2c\sqrt{K_a} \qquad \text{..} \qquad \textbf{(2.1)}$$

$$p_p = K_p \gamma h + 2c\sqrt{K_p} \qquad \text{..} \qquad \textbf{(2.2)}$$

where $K_a = 1 / K_p$ Coefficient of active lateral earth pressure = $(1 - \sin\phi) / (1 + \sin\phi)$, ϕ is the angle of internal friction of soil; γ = dry unit weight of soil; h = any depth below horizontal ground surface; c = cohesion of soil.
When a cut is made in soils, active lateral earth pressure comes into being due to the gravitational geostatic stress in soil, it may be increased if surface loads are applied (induced stresses). Keeping this aspect in view, equation (2.1) is used to find the depth of tension crack, h_c, in soil for p_a = zero condition. This will turn equation (2.1) into equation 2.3 for h_c.

$$h_c = \frac{2\sqrt{K_a}\,c}{\gamma K_a} \qquad \text{...} \qquad \textbf{(2.3)}$$

h_c is a function of shear strength parameters c and ϕ; and unit weight of soil, γ.

But the theoretical depth of cut, H_c, is two times of h_c where the sum of the negative active lateral earth pressure and of an equal amount of positive active lateral earth pressure is zero. This can be seen from figure 2.1. Moreover, Das (2007) quotes Meyerhoff for work on the critical depth H_c, for a slurry stabilised long trench in saturated clay with cohesion, $c = c_u$ and $\phi = 0$, Ka = 1), at which P_a is equal to zero ($H > H_c$ failure will occur) and he calculated this critical unsupported depth of cut as equation 2.4. According to the work of Zhang et al (1998), this depth can be increased or the section of supporting system can be economized due to the constrained soil in the back.

$H_c = 2\,h_c = 4c_u / (\gamma - \gamma_s)$, ... **(2.4)**

where γ_s is the unit weight of slurry.

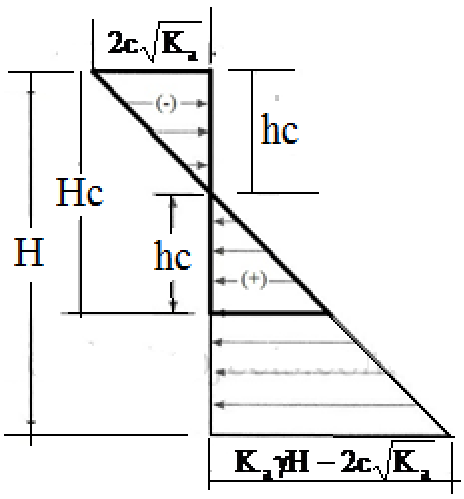

Figure 2.1: Theoretical depth of cut, Hc, in c - ϕ soil.

Because of cohesion, c or no friction, in soil, deep cliffs with vertical facing can be seen in clayey soils but in dry sands H_c is zero because of no cohesion. This no depth of cut in sands can be seen from Peck (1969) work on the active lateral earth diagram (figure 2.2) after a great deal of study of actual pressure measurements on braced cuts used for subways. This pressure diagram is applicable to both loose and dense sands. At depth $H_c = 0$, the active soil pressure is $p_a > 0$, which means that the sand cannot retain any depth of cut. The expression for active lateral earth pressure, p_a by Peck (1969) is given by equation 2.5:

$$\mathbf{p_a = 0.65\,\gamma H K_a} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2.5)$$

where, $K_a = \tan^2(45 - \phi/2)$ and γ= unit weight of sand.

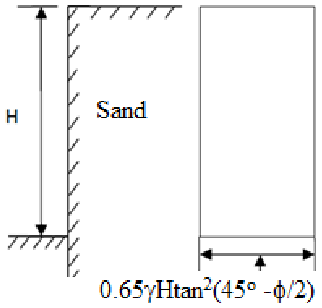

Figure 2.2:Apparent pressure digram for calculating loads in struts of braced cuts; Sketch of wall cut with active lateral earth pressure distribution in dry sand or moist sand (Peck, 1969).

III. Method and Results

3.1 Method: The addition of ordinary Portland cement with poorly graded sand is envisaged to impart cohesion to sand. The samples of cemented sands are prepared for direct shear test apparatus of the size 60mm x 60mm x 37mm. These samples are prepared with cement mixed in dry state in 3%, 4%, 5%, 6% and 7% by dry weight of the dry sand. This cement - sand mixture is thoroughly mixed with potable water and the paste is cast in moulds of the above mentioned size and cured for 7 days in water tub at ordinary temperature.

3.2 Results (Sand Properties): Figure 3.1 shows the particle size distribution of the sand and Table 3.1 shows some properties of the sand having a specific gravity of solids, Gs, equal to 2.65 on the basis of which this sand is considered to be silica in nature. And according to unified soil classification system, the sand is graded as poorly graded with little fines of about 2%. The feature of poorly graded sand is that uniform soil particles dominate and cement slurry injection is easy in the field which can then be cut without external support on curing.

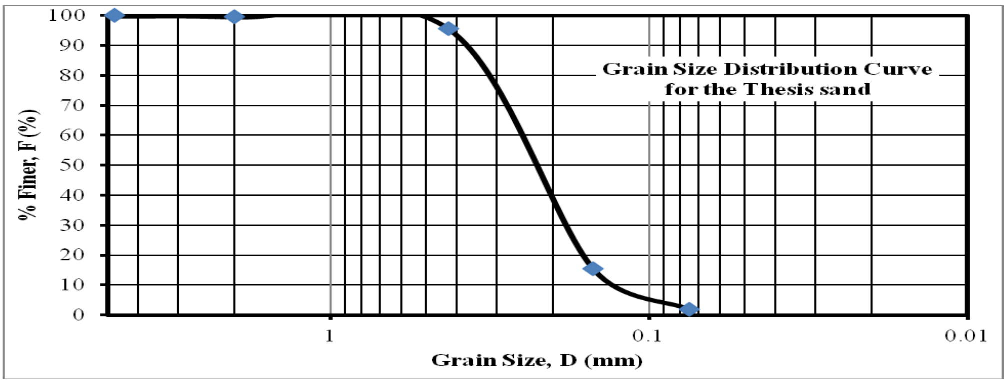

Figure 3.1: Particle size distribution of the sand used in this study.

Table 3.1: Gradation and specific gravity of sand.

Particle size, D-values (mm)				**Gradation-values, ratio**		**Gradation**
Effective Size, D_{10}	***Mass-median-diameter, D_{50}**	**D_{30}**	**D_{60}**	**uniformity coefficient, Cu**	**Concavity coefficient, Cc**	**USCS classification**
0.15	**0.22**	**0.18**	**0.25**	**1.67**	**0.86**	**SP (poorly graded sand with no fines). Solids Specific gr, Gs=2.65**
*The Mass Median Diameter is considered to be the average particle diameter of mass of 50% of the total.						

The direct shear tests produce the shear strength parameters of angle of internal friction, $\phi = 35^{O}$ shown in figures 3.2 and 3.3 under three normal stresses of 125 kPa, 250 kPa and 375 kPa on the pure sand i.e. 0% cement mixed.

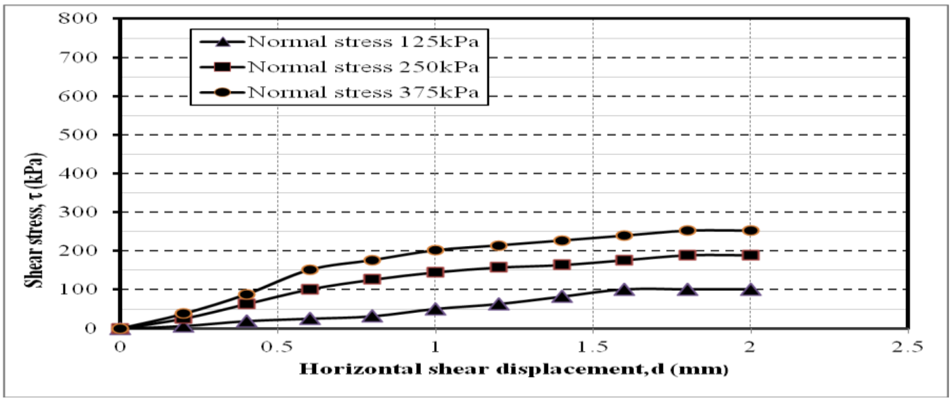

Figure 3.2: Direct shear tests results on pure sand.

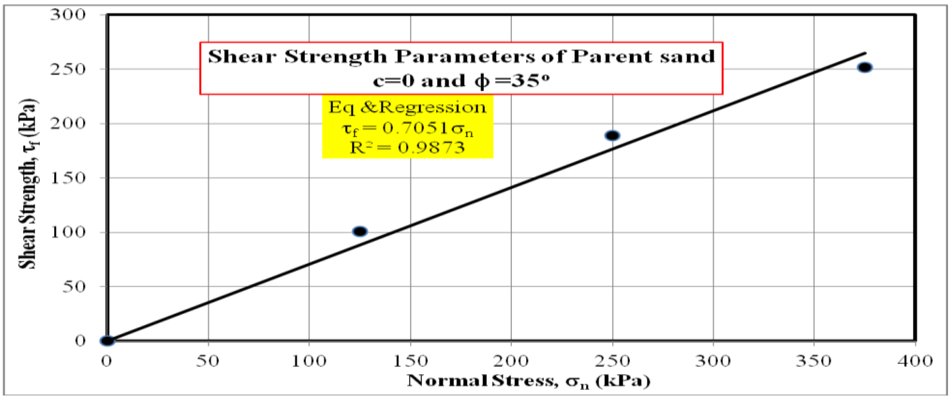

Figure 3.3: Shear strength parameters of pure sand used in this work.

3.3 Results (Cemented Sand): Direct shear tests are conducted on sand mixed with cement in the ratios of 3%, 4%, 5%, 6% and 7% by dry weight of sand. Three tests are conducted on each ratio under normal stress of 125kPa, 250kPa and 375kPa. The results of all eighteen tests are plotted in figure 3.4. It is seen from the graph that increase in cement content increases the added cohesion in the sand but the angle of internal friction of sand decreases from 35°, however the overall shear strength increases. A shear strength up to 800kPa is reasonable in soils, that is why content of 7% is the maximum limit in this study. For comparison of this work with the works of others, Wang and Li (2016) conduct shear strength tests on 4.2% cemented sand as shown in figure 3.5. Their cohesion and the added cohesion in this work sand almost matches with a values of about 400 kPa.

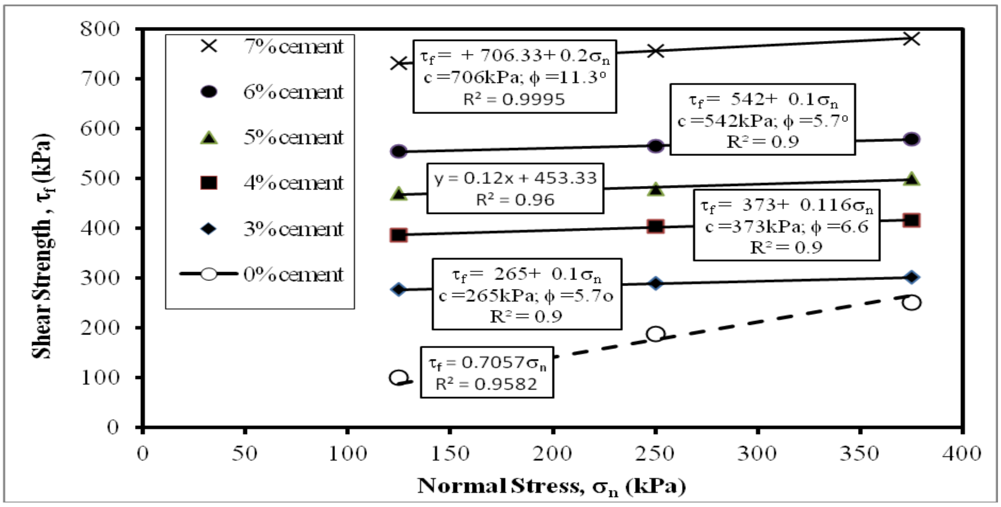

Figure 3.4: The added cohesion to the cemented sand measured in direct shear tests.

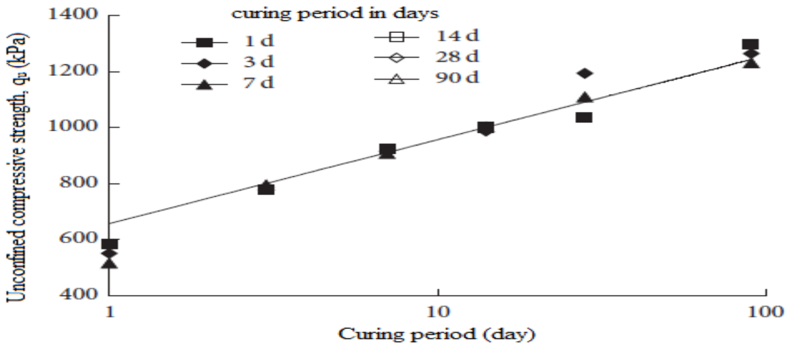

Figure 3.5: Relationship of uncofined compressive strength - curing period, (Wang and Li, 2016)

3.4 Results (Depth of Unsupported Cut in cemented sand): The data from figure 3.4 are analyzed for the depth of unsupported cut in cemented sand using the Rakine theory of lateral earth pressure. Using the Rankine theory on active lateral earth pressure and Meyerhof equation 2.4 for no slurry in the long trench or cut in the cemented sand, the depth of unsupported cut or critical depth of cut, Hc, is plotted in figure 3.6 as a function of added cement, x %. It can be seen that the depth increases with the amount added cohesion in the sand mixed with ordinary Portland cement. Theoretically, it can go on increasing unto the cohesion of pure cement which is not the case in soil mechanics.

Nemati, (2005) mentions the theoretical safe heights, H (m) for homogeneous clays cut with vertical walls / slopes. His work is shown in table 3.2 for comparison.

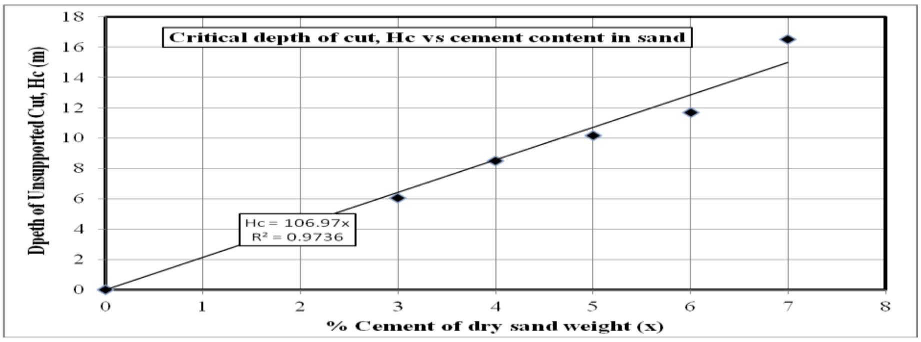

Figure 3.6: Unsupported depth of cut, Hc, in sand cemented with ordinary portland cement content, x%.

Table 3.2: Theoretical safe heights for homogeneous clays cut slope with vertical walls (Nemati, 2005).

Soil Consistency	**Cohesion, c (kPa)**	**Safe height, H (m)**
very soft	<125	<1.25
soft	125-250	1.50 -3
medium	250-500	3- 6
stiff	500 - 1000	6 - 12
very stiff	1000 – 2000	12 -24
Hard	>2000	> 24

References:

[1]. Das, Braja M. (2007). Theoretical Foundation Engineering, J. Ross Publishers.
[2]. Nemati, Kamran M., 2005. Excavations and Excavations Supports, Advance Topics in Civil Engineering, Tokyo Institute of Technology.
[3]. Peck, R.B., 1969. Deep excavations and tunneling in soft ground. Proc. 7th Int. Con. SMFE, State of the Art, pp.225-290.
[4]. Wang, Cheng and Li, Wentao (2016). Factors Affecting the Mechanical Properties of cemented – Mixed Gravel, Advances in Materials Science and Engineering, Volume 2016, Article ID 8760325, Hindawi Publishing Corporation.
[5]. Zhang, J., Shamoto, Y. and Tokimatsu, K., 1998. Evaluation of earth pressure under any lateral deformation. Soils and Foundations, 38(1), pp.15-33.

Noor Ul Amin "Depth of Cuts in Cement Stabilized Sand "International Journal of Engineering Science Invention (IJESI), vol. 07, no. 07, 2018, pp 01-05