Evaluation of the Parameters Affecting the Cohesion of Fine Grained Soil

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Abstract. Cohesion of the soils is one of the most important parameters which soil is evaluated in terms of its suitability for building foundations. Safety of construction is in fact dependent on the strength of soil, respectively shear strength. Fine-grained soil represents very specific group, in which is distinguished an effective and total cohesion of soils. The water in the soil thus drastically affects its cohesion contrary to gravel and sandy soils. The publication compares the tabular values of the effective and total cohesion and define the influence of water, grain size and consistency of her behaviour.

1. Introduction

Cohesion soils can be defined as the extent of those powers, connecting the soil particles. Cohesion is absolutely essential for determining the shear strength of soil, because soils are most often violated in shear. Because the soil is three-phase, it is distinguished effective and total cohesion parameters. However, that applies only in the case of fine-grained soil. It is however important to note that the shear strength has only a solid phase. Liquid and gaseous phases only transmits tension. However, the interaction of these phases which may be in varying proportions, affects the strength characteristics of the soil.

The fact that the water affects the behaviour of particularly fine grained soil is due to particle size, it means grains of below 0.02 mm. Water is able to create around the fixed parts of the packaging in case of silt and clay. It is bound by electro-molecular and electrochemical forces. Therefore, in the case of fine grained soil, there are different states of consistency. This ability thus significantly affects the physical and mechanical properties of soils. Effective and total stress in soil but looking only at the normal stress. Shear stress is always effective.

2. Effective and total cohesion of fine grained soil

As mentioned in the introduction, in the case of fine grained soil is needed to distinguish between effective and total cohesion. Effective cohesion of soils understand cohesion, in which the pores are not filled with water. Values of effective cohesion grows with decreasing grain. That is, the larger the area of contact surface of the grain.

The effective stress is expressed by the equation (1):

$$\sigma_{ef} = \sigma - u \tag{1}$$

wherein σ_{ef} is effective stress (kPa), σ is the total stress (kPa), u is neutral stress or pore pressure (kPa). The effective strength is then expressed by the equation (2):

$$\tau = (\sigma - u) * tg\varphi_{ef} + c_{ef} \tag{2}$$

Wherein τ is tangential stress to the shear surface (kPa), σ is the normal stress acting perpendicular to the shear surface (kPa), u is neutral stress or pore pressure (kPa), tgφef effective angle of internal friction of soil (°), cef is effective cohesion (kPa)

Effective cohesion of fine grained soil is defined on the basis of the standard CSN 73 1001 for different states of consistency and degree of saturation. Defined as the consistency of soft to hard. The degree of saturation is defined for consistency firm and hard, where is distinguished the degree of saturation of less than 0.8 and the degree of saturation greater than 0.8. Based on the assessment values of the effective cohesion of fine-grained soils (Figure 1) can be said that the lowest values are recorded for a plastic consistency for all classes. Minimum values for plastic consistency varying from 4 kPa for class F1 with a gradual increase to 10 kPa at class F4 and gradually decreasing down to 2 kPa for class F8. This is in contrast to 8 kPa, respectively. up to 5 times greater. The trend is similar in terms of the maximum tabulated values of the plastic consistency. This means that there is a progressive increase of consistency class F1 (12 kPa) to the class F4 (18 kPa) with a gradual reduction after class F8 (8 kPa).

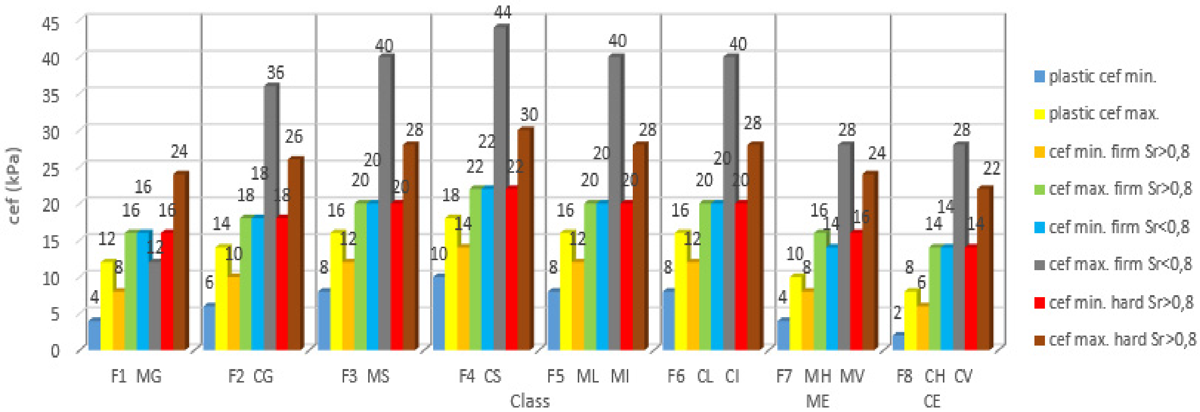

Figure 1. Effective cohesion of fine grained soil according to [1]

There is a difference of 10 kPa, more than double the lowest values. The second group of the lowest value in the range of all classes is a firm consistency at their minimum levels and degree of saturation greater than 0.8 but with the same trend. The maximum value is thus to class F4 (14 kPa) and gradually decreases to the minimum value 6 kPa of class F8. The publication also draws on the knowledge, which are listed in [2, 3, 7, 12].

Completely identical values are reported in fine-grained soils with a firm consistency, with degree of saturation greater than 0.8 in their maxims and hard soil with the degree of saturation greater than 0.8

at their minimums. Both groups rise from a value of 16 kPa for a class F1 to 22 kPa for Class F4 with a gradual reduction to 14 kPa for class F8. Same values also achieve soil, with a firm consistency, the degree of saturation of less than 0.8 in their minimums. The difference is only in F7, which represents 2 kPa. Very significant jump represents values of the effective cohesion of firm consistency, degree of saturation of less than 0.8 at their maximum. In the case of class F1 is a value only 12 kPa, but for class F2 to threefold increases to 36 kPa. Whereas trend is very similar to that of the previous Atterberg states with maximum class F4, with a value of 44 kPa and gradually decreases to the value of 28 kPa for F7 and F8. Hard consistency, with degree of saturation greater than 0.8 represents the last group, but the other with a highest value. It is 24 kPa class F1 to 30 kPa for class F4. The lowest values are at the last class F8, which is 22 kPa.
For Class F3, F5 and F6 in each state of consistency, the values are identical. As regards the comparison of classes, wherein the predominant silt or clay, it is obvious that clay exhibit in all classes better values than in silt. This is due to the fact that clay among themselves better able binding by means of electro-molecular forces and there are capillary forces. The fact that the values for the class F1 to F4 rising is caused by an increasing proportion of smaller particles. Conversely, in class F5 to F8, is to reduce cohesion, which is caused by increasing plasticity because more plastic soils bind more water. The issue of consistency of soils is also mentioned in publications [2, 6, 8, 12, 14].

Regarding the degree of saturation, it is clear that the soil with degree of saturation less than 0.8 achieve overall better values. When the degree of saturation of more than 0.8 are electro-molecular forces weakened by increasing the distance between the grains. For the last group, hard consistency with the degree of saturation of less than 0.8 values are not defined in a table, determined up to the basis of tests.

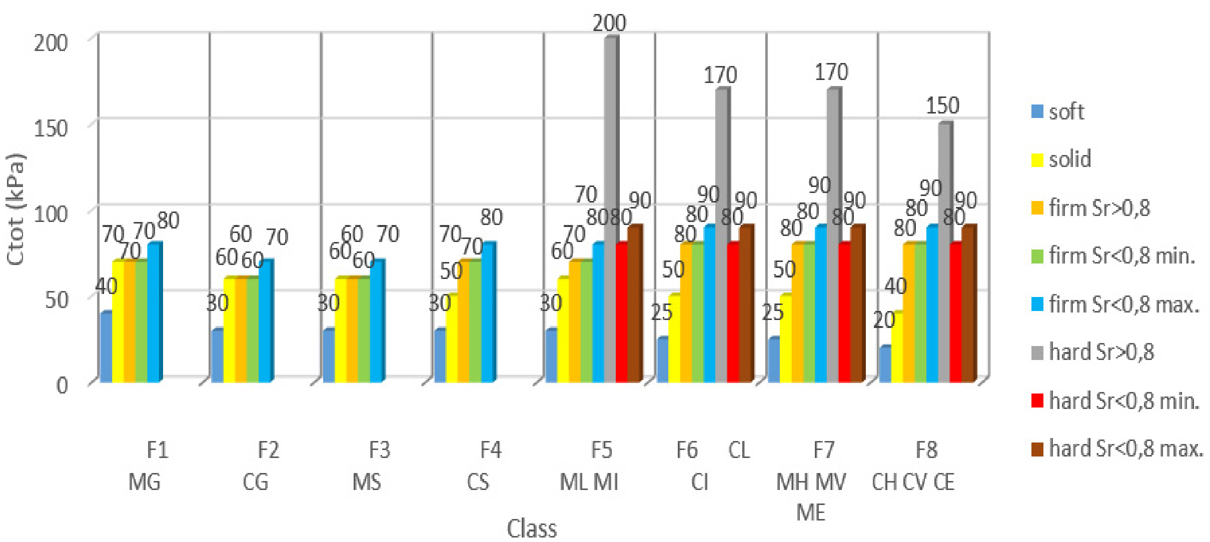

Figure 2. Total cohesion of fine-grained soils according to [1]

Values of hard consistency are not available in case of class F1 to F4, in terms of fine-grained soils with values of total cohesion (Figure 2). In the case of total cohesion is calculated with water. Total parameters are used on cohesive soils assuming they do not change the water content in the pores. Total stress is the sum of effective stress and pore pressure (3):

$$\sigma = \sigma_{ef} + u \tag{3}$$

whereas σ is the total stress (kPa),
σ_{ef} is effective stress (kPa),
u is neutral stress or pore pressure (kPa).

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Total strength is then expressed by the equation (4):

$$\tau = \sigma * tg\varphi_u + c_u \quad (4)$$

Whereas τ is tangential stress to the shear surface (kPa), σ is the normal stress acting perpendicular to the shear surface (kPa), tg φu is total angle of internal friction soils (°), cu is total cohesion (kPa).

Values of total cohesion of soils are significantly higher than the effective cohesion. Soils that have a soft consistency in all classes, reaching their lowest levels. These range from 40 kPa for class F1 and gradually decreasing to half, that is 20 kPa for Class F8. Whereas value of 30 kPa is holding for F2 to F5 classes. Another group represents a solid consistency. Values also have a downward trend since F1 class of 70 kPa to 40 kPa for class F8, except for the class F4, where decrease to 50 kPa and another increase of class F5 to the 60 kPa. The pair Atterberg states with identical values in the range of all classes is firm consistency with a degree of saturation greater than 0.8 and the firm consistency with a degree of saturation of less than 0.8 in their minimums. Trends in these two groups is fluctuating with a maximum difference of 20 kPa, while the values of total cohesion can be divided into three groups. This is a class F2 and F3 with the lowest value of 60 kPa, class F1, F4 and F5 of 70 kPa, and the last group with the highest value of 80 kPa at class F6 to F8. As regards maximums firm consistency with a degree of saturation of less than 0.8, then we can say that the values are about 10 kPa higher in each class than in previous group.

As already mentioned, thus values of hard consistency are known only in the case of class F5 to F8. The highest values in the range of all consistency is hard consistency with degree of saturation greater than 0.8. Values are ranges from 200 kPa for Class F5 to 150 kPa for Class F8. Hard consistency with the degree of saturation of less than 0.8 is moving in its maximum and minimum constantly in the range 80 to 90 kPa for a defined class F5 to F8. To extend knowledge in link with cohesion of soils this article refers to the publication [4, 9, 10, 11]

3. Conclusions

Defining the effective and total parameters of fine-grained soils is crucial to understanding their behaviour. It is necessary to recognize the effects of individual components on the cohesion parameter given that the soil is a three-phase, respectively. It is composed of solid, gaseous and liquid phases. It is obvious that the total characteristics have of significantly higher values than the effective parameters for which are not considering the water in the pores. This is the difference up to 156 kPa when comparing maximum values. It is 18 kPa when comparing the lowest values for both cohesions. Simultaneously, there is a completely different development trend of values. Values increase in the case of effective parameters of class F1 up to F4 class. This is due to an increasing proportion of smaller particles. Subsequently being reduced up to class F8. This lowering of the cohesion is due to increasing plasticity because more plastic soils binds more water. Simultaneously plasticity plays a significant role. As regards the comparison of classes, wherein the predominant silt or clay, it is obvious that the clay has better values in all classes than in silt.

Conversely, to reduce cohesion occurs between classes F5 and F8, which is caused by increasing plasticity. More plastic soils bind more water. The degree of saturation plays another important role. Soils with the degree of saturation of less than 0.8 have a better value in the case of a firm consistency.

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