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DETERMINATION OF THE SHEAR STRENGTH PARAMETERS OF CLAY FOR THE HIGH-SPEED TRAFFIC LINE NOVI SAD-RUMA

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Abstract

Determining the parameters of soil shear strength is of key importance in geotechnical engineering because it affects the stability and load-bearing capacity of various building structures. Relevant data on the shear strength of the soil from previous laboratory tests for the route of the future expressway Novi Sad - Ruma are being collected. These data include shear strength values and various factors that can affect this strength, such as soil composition, moisture, density and other geotechnical factors. After data collection, descriptive statistics methods are applied to identify the basic characteristics of the shear strength data set. These methods include calculating the arithmetic mean, standard deviation, quartiles, minimum and maximum. Additionally, histograms and probability density distribution functions are shown to visualize the data distribution. Based on the obtained results, trends and variations in soil shear strength are investigated. This provides insight into the statistical significance of parameters and helps in understanding their variability in different geological formations or in different locations.

***Keywords**: descriptive statistics, soil strength parameters, geostatistics*

1. INTRODUCTION

The shear strength of the soil is a geotechnical parameter that has a significant impact on the stability and load-bearing capacity of various constructions, from building foundations to dams and roads. Analysis of this parameter and understanding of its characteristics are essential for successful planning and execution of construction projects, both in urban areas and in rural areas. Accordingly, this paper focuses on the application of descriptive statistics as a powerful tool for analyzing soil shear strength parameters. Descriptive statistics enable the systematic organization and summarization of data, providing insight into the basic characteristics of the data set and forming the foundation for further statistical analyses. One of the key aspects of this work is data visualization using a histogram, a probability density function. This kind of visual display enables a clearer view of the distribution of data and the identification of possible deviations or characteristic patterns. This multidisciplinary approach should become part of everyday practice in understanding soil behavior in different conditions. Ultimately, this analysis will provide a strong basis for making reliable decisions and designing safe and efficient building structures to suit specific soil conditions. In this research, methods for the statistical evaluation of shear strength parameters will be applied on the example of the state road No. 21 Novi Sad - Ruma - Šabac. The projected

road runs southwest from Irig through the locality "Budakovac" all the way to the intersection for Vrdnik, and then it fits into the existing road to Ruma.

2. RESULTS AND DISCUSSION

2.1 Characteristic value for highly plastic clay

This group of highly plastic CH clays includes the following lithological units: deluvial-proluvial sediments, Pontic clays and carbonaceous clays, Lower Miocene altered siltstones, argillaceous dusts and altered conglomerates.

Table 1. *Results of laboratory tests (Hidrozavod DTD, 2021)*

Ordinal number	Depth (m)	w	wl	wp	n	e	( )	tg	C (kPa)	USCS
1	4.2	40.8	119	35	52.1	108.7683	9	0.158384	16	CH
2	4.3	32.9	50	23	49.0	96.07843	12	0.212557	12	CI/CH
3	2.1	47.0	121	44	56.9	132.0186	12	0.212557	17	CH
4	2.1	39.2	110	39	57.1	133.1002	14	0.249328	15	CH
5	13.2	35.5	86	36	48.7	94.93177	14	0.249328	29	CH
6	11.4	40.7	121	42	54.7	120.7506	14	0.249328	35	CH
7	9.3	36.4	76	31	50.8	103.252	15	0.267949	10	CH
8	5.0	49.7	101	41	59.7	148.139	15	0.267949	20	CH
9	5.0	23.8	60	23	40.2	67.22408	15	0.267949	26	CH
10	11.4	16.1	52	22	30.1	43.06152	16	0.286745	24	CH

2.2 Determination of the angle of internal friction for highly plastic clay

Table 2. shows the basic descriptive parameters of the angle of internal friction tg φ for highly plastic clay on the route of the Fruškogorski Corridor. Based on the obtained results, it can be established that the average value of the tangent of the internal friction angle is 0.322 with a standard deviation of 0.08. The coefficient of variation of the internal friction angle is 25%.

Table 2. *Results of laboratory tests (Hidrozavod DTD, 2021)*

Mean value ($\overline{X}$)	Coefficient of variation (v) (%)	Standard deviation (S)
0.322	25	0.08

The characteristic values of the given parameter were determined for two cases when the coefficient of variation is known and when the coefficient of variation is unknown. In the case when the coefficient of variation is known, the values $X_{c,low}$ = 0.187 and $X_{c,mean}$ = 0.297 are obtained, i.e. $X_{c,low}$ = 10.6° and $X_{c,mean}$ = 16.5°. The

obtained results of the characteristic value $X_{c,mean}$ and $X_{c,low}$ when the value of the coefficient of variation is known are presented in Figure 1.

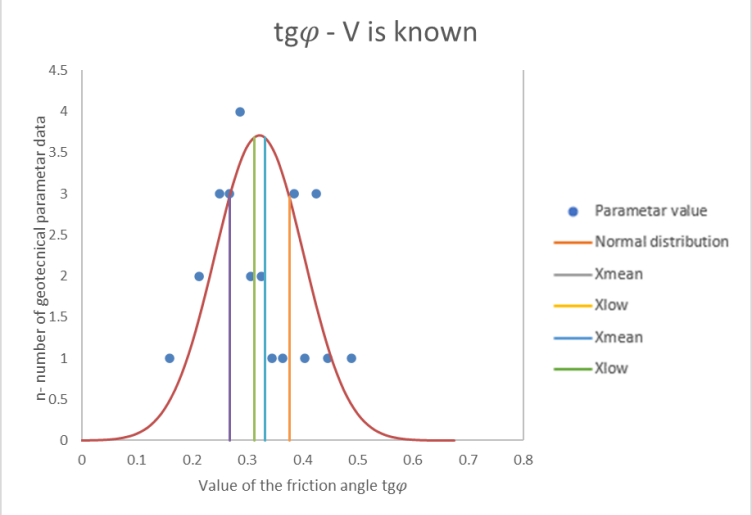

Figure 1. *Graphic representation of the statistical analysis of the angle of internal friction when the coefficient of variation is known*

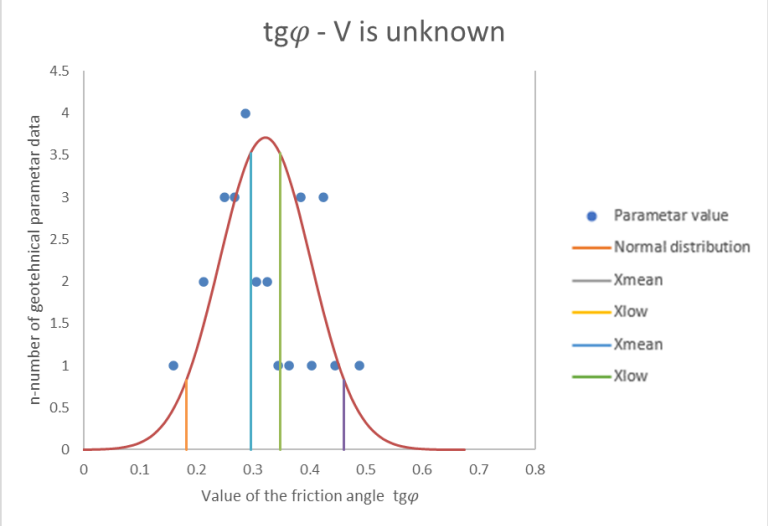

Figure 2. *Graphic representation of the statistical analysis of the angle of internal friction when the coefficient of variation is unknown*

In the case when the coefficient of variation is unknown, the values $X_{c,low}$ = 0.182 and $X_{c,mean}$ = 0.296 are obtained, i.e. $X_{c,low}$ = 10.3° and $X_{c,mean}$ = 16.5°. The obtained results of the characteristic value $X_{c,mean}$ and $X_{c,low}$ when the value of the coefficient of variation is not known are presented in Figure 2.

Table 3. *Data processing of tangent angle of internal friction for highly plastic clay*

Ordinal number	tg	x -xi	|x-xi|	$(x-xi)^2$	|x-xi|>v
1	0.158384	0.163541	0.163541	0.026746	condition met
2	0.212557	0.109369	0.109369	0.011962	condition met
3	0.212557	0.109369	0.109369	0.011962	condition met
4	0.249328	0.072597	0.072597	0.00527	condition met
5	0.249328	0.072597	0.072597	0.00527	condition met
6	0.249328	0.072597	0.072597	0.00527	condition met
7	0.267949	0.053976	0.053976	0.002913	condition met
8	0.267949	0.053976	0.053976	0.002913	condition met
9	0.267949	0.053976	0.053976	0.002913	condition met
10	0.286745	0.03518	0.03518	0.001238	condition met
$\Sigma\sum$ *suma*	2.422074			0.076457	

2.3 Determination of cohesion for highly plastic clay

Table 4. shows the basic descriptive parameters of cohesion c for highly plastic clay on the route of the Fruškogorski corridor. Based on the obtained results, it can be established that the mean value of cohesion is 26.14 kN/m^2 with a standard deviation of 13.73. The coefficient of variation of cohesion is 52.5%.

Table 4. *Results of laboratory tests (Hidrozavod DTD, 2021)*

Mean value ($\bar{x}$)	The coefficient of variation (v) (%)	Standard deviation (S)
26.14	52.5	13.73

To define the characteristic value of a given parameter, two cases were performed when the coefficient of variation is known and when the coefficient of variation is unknown. In the case when the coefficient of variation is known, the values $X_{c,low}$ = 3.16 and $X_{c,mean}$ = 21.88 are obtained. The obtained results of the characteristic value $X_{c,mean}$ and $X_{c,low}$ when the value of the coefficient of variation is known are presented in Figure 3.

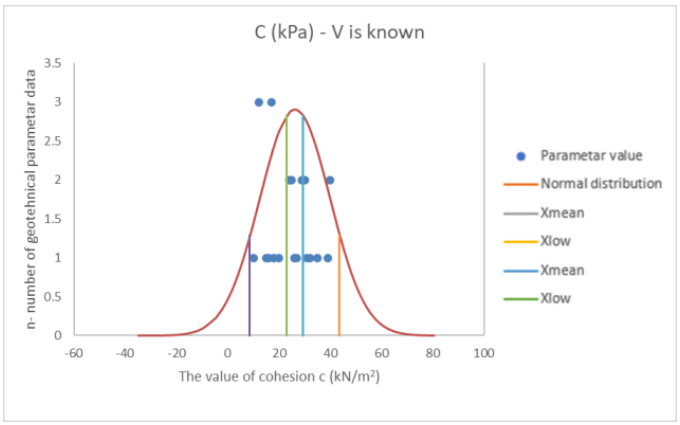

Figure 3. *Graphic representation of the statistical analysis of cohesion when the coefficient of variation is known*

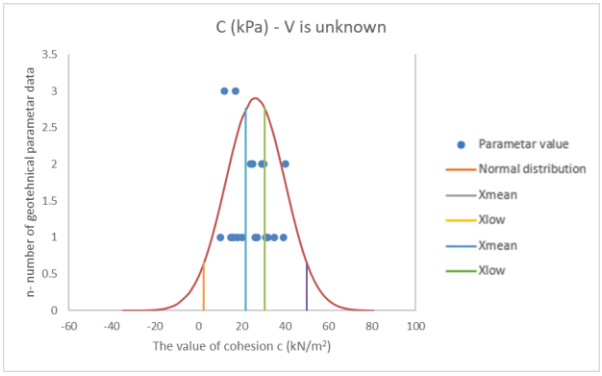

Figure 4. *Graphic representation of the statistical analysis of cohesion when the coefficient of variation is unknown*

In the case when the coefficient of variation is unknown, the values $X_{c,low}$ = 2,39 $\frac{kN}{m^2}$and $X_{c,mean}$ = 21,73 $\frac{kN}{m^2}$ are obtained. The obtained results of the characteristic value $X_{c,mean}$ i $X_{c,low}$ when the value of the coefficient of variation is not known are presented in Figure 4.

Table 5. *Processing of cohesion data for highly plastic clay*

Ordinal number	C (kPa)	x-xi	|x-xi|	(x-xi)^2	|x-xi|>v
1	16	10.14286	10.14286	102.8776	condition met
2	12	14.14286	14.14286	200.0204	condition met
3	17	9.142857	9.142857	83.59184	condition met
4	15	11.14286	11.14286	124.1633	condition met
5	29	-2.85714	2.857143	8.163265	condition met

6	35	-8.85714	8.857143	78.44898	condition met
7	10	16.14286	16.14286	260.5918	condition met
8	20	6.142857	6.142857	37.73469	condition met
9	26	0.142857	0.142857	0.020408	condition met
10	24	2.142857	2.142857	4.591837	condition met
Σ suma	204			900.2041	

3. CONCLUSION

Analyzing the shear strength parameters for highly plastic clay, the values were obtained (cohesion: $X_{c,low}$ = 3.16 KPa, X_{cmean} = 21.88 KPa and X=21.19 KPa; internal friction angle: $X_{c,low}$ = 10.3, $X_{c,\ mean}$ = 16.5 and X= 16.5). Based on the obtained results, we can conclude that, according to Eurocode 7, approximately equal values of the angle of internal friction are obtained for highly plastic clay, while the obtained results related to cohesiveness completely match for highly plastic clay.

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