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STATISTICAL DATA PROCESSING OF INTERLABORATORY DETERMINATION OF HYDRAULIC CONDUCTIVITY

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Abstract

The paper presents the results of an interlaboratory study involving four participating laboratories in the test method: "Determination of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter." The soil samples were collected from the Zlaća region, in the vicinity of the city of Bor. The results were statistically analyzed using two approaches, namely: Numerical method: z-score, and Graphical interpretation: Mandel's consistency technique in accordance with the SRPS ISO 5725-2 standard. The following were calculated: repeatability variance (Sr^2), interlaboratory variance (SL^2), and reproducibility variance (SR^2). The samples were distributed to all participating laboratories using the sample splitting method.

***Keywords**: statistical data processing, interlaboratory studies, determination of hydraulic conductivity of saturated porous materials using a flexible wall permeameter, SRPS ISO 5725-2 standard.*

1. INTRODUCTION

Four accredited laboratories participated in these tests. The interlaboratory study for the determination of hydraulic conductivity of saturated porous materials using a flexible wall permeameter was conducted in accordance with the ISO 17313:2004 standard. The tests were performed on undisturbed soil samples collected from the agricultural land of Zlaća, in the vicinity of the village of Zlot, city of Bor. The results were statistically processed using the numerical z-score method and graphically interpreted according to Mandel's consistency technique. In order to provide a comparative analysis of the achieved results, the calculations of the basic and necessary parameters for the interlaboratory studies considered results based on the same computations.

The repeatability variance, interlaboratory variance, and reproducibility variance were also estimated.

2. EXPERIMENTAL

Experimental tests were performed on undisturbed soil samples, using the constant-head method in a flexible wall permeameter, Figure 1.



Figure 1. *Laboratory permeameter*

During the process, a constant water flow was maintained under a defined cell pressure to simulate real soil conditions and ensure full saturation of the porous medium prior to the measurement itself. The tests were performed in three replicates. [1,4]

The coefficient of permeability was calculated according to the formula in accordance with the aforementioned standard:

$$k = \frac{Q \cdot h}{L \cdot F \cdot t}, cm/\sec \text{ [1]}$$

3. RESULTS AND DISCUSSION

Results of the determination of hydraulic conductivity of saturated porous materials using a flexible wall permeameter are given in Table 1 [3,4].

Table 1. *Obtained values by test trials [3,4]*

Lab. ID	Obtained values by test trials		
	I	II	III
1.	2.13×10^{-5}	2.18×10^{-5}	1.92×10^{-5}
2.	1.4×10^{-4}	1.0×10^{-4}	1.0×10^{-4}
3.	2.2×10^{-4}	2.3×10^{-4}	2.4×10^{-4}
4.	1.31×10^{-5}	1.29×10^{-5}	1.33×10^{-5}

Results of cell means are given in Table 2 [3,4].

Table 2. *Cell means [3,4]*

Lab. ID	$\bar{X}$	$\bar{X}^2$
1.	0.0000207667	0.0000000004
2.	0.0001133333	0.0000000128
3.	0.0002300000	0.0000000529
4.	0.0000131000	0.0000000002
	$\bar{\bar{X}}$=0.000094	

Results of calculated variance are given in Table 3 [3,4].

Table 3. *Calculated variance values [3,4]*

Sr^2	Sr	S_L^2	S_L	S_R^2	S_R
1.588E-10	1.26E-05	1.0206E-08	0.000101	1.0365E-08	0.000101809
Sr^2- Repeatability variance ***S_L^2 - Interlaboratory variance*** ***S_R^2- Reproducibility variance***					

Note: The repeatability, reproducibility, and interlaboratory variances were calculated according to the formulas provided in clause 7.4.5 of the SRPS ISO 5725-2 standard. [3,4]

Note: Due to random effects, any negative values obtained for SL2 are considered equal to zero (clause 7.4.5.4 of SRPS ISO 5725-2). [3,4]

Results of calculated z-values are given in Table 4 [3,4].

Table 4. *Calculated z-values [3,4]*

Lab. ID			
1	2	3	4
Calculated z-values			
-0.72	0.19	1.33	-0.80
Acceptable value	Acceptable value	Acceptable value	Acceptable value

Graphical interpretation of z-score is given in Figure2.

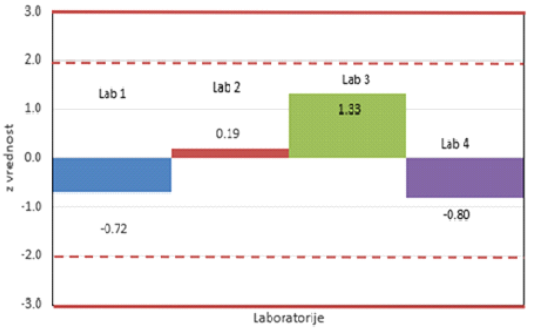


Figure 2. Graphical interpretation of z-score

Calculated h-values is given in Table 5 [3,4].

Table 5. Calculated h-values [3,4]

Lab. ID	1.	2.	3.	4.	h-indicator	
					1%	5%
	Calculated h-values					
	-0.95 Acceptable value	-0.08 Acceptable value	1.02 Acceptable value	-1.02 Acceptable value	**1.49**	**1.42**

Graphic representation of calculated h values is given in Figure 3.

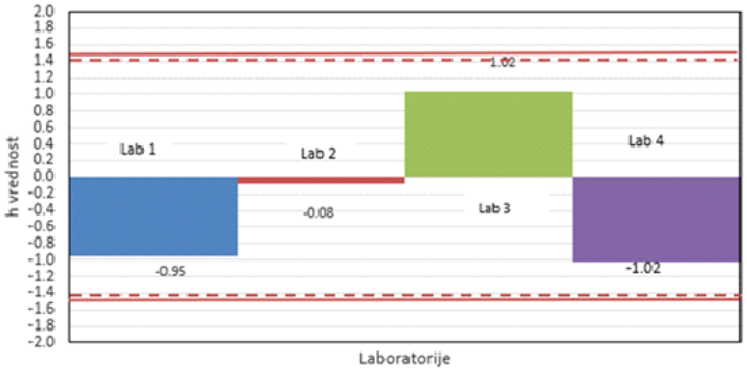


Figure 3. *Graphic representation of calculated h values*

Calculated k values is given in Table 6 [3,4].

Table 6. *Calculated k values [3,4]*

Lab. ID	1.	2.	3.	4.	k-indicator	
					1%	5%
	Calculated k-values					
	0.12 Acceptable value	2.05 Outlier	0.89 Acceptable value	0.02 Acceptable value	**1.77**	**1.59**

Graphical representation of calculated k-values is given in Figure 4.

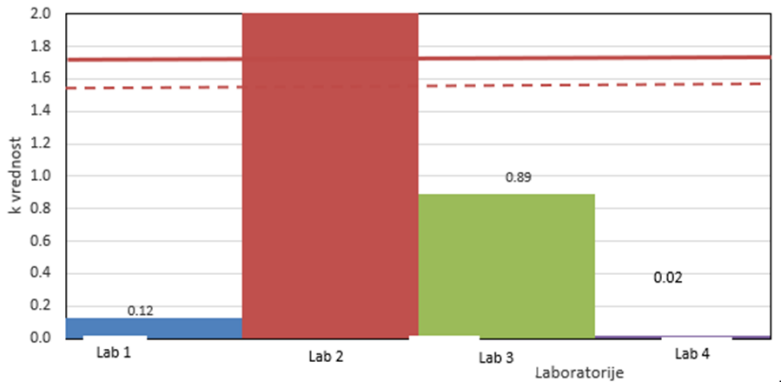


Figure 4. Graphical representation of calculated k-values

4. CONCLUSION

The purpose of this paper is to evaluate the precision of the test method and assess the capability of the testing laboratories. Following the statistical processing of the results using two methods—graphical and analytical—the following conclusion can be drawn. By processing the results with the z-score statistical method, it is concluded that none of the results exceeded the action limits; that is, all results are within acceptable limits. According to Mandel's graphical interpretation, the values of the h and k statistics are lower than the critical h and k table values for the 5% and 1% significance levels, except for the k-value of laboratory number 2, which is considered an outlier. Based on a comprehensive analysis of the obtained results, a good level of competence among the laboratories for the application of the specified method can be established. [5]

Note: Possible influencing factors/effects on the final test results should also be taken into consideration:

-Sampling (homogeneity).
-Sample preparation (homogenization effect).
-Operator/sampler influence.

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