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STATISTIČKA OBRADA REZULTATA MEĐULABORATORIJSKOG ISPITIVANJA GRANULOMETRIJSKOG SASTAVA PESKA I ŠLJUNKA IZ ZAPADNOG DELA KOSTOLAČKOG BASENA****

Izvod

U radu su prikazani rezultati međulaboratorijskog ispitivanja granulometrijskog sastava peska i šljunka, na reprezentativnim uzorcima, sa lokaliteta zapadnog dela kostolačkog basena. Rezultati su statistički obrađeni na dva načina i to: **Numeričkom metodom: Cochran-ov test preciznosti i Grafičkom interpretacijom: MANDEL-ova tehnika konzistentnosti u skladu sa standardom SRPS ISO 5725-2** [1,2].

Izračunate su: Varijansa ponovljivosti S_r^2 ; međulaboratorijska varijansa S_L^2 i varijansa obnovljivosti S_R^2 .

Uzorci su metodom deljenja dostavljeni svim laboratorijama učesnicama.

Gljučne reči: statistička obrada rezultata, međulaboratorijska ispitivanja, granulometrijski sastav, standard SRPS ISO 5725-2

1. UVOD

U ovim ispitivanjima učestvovala su četiri akreditovane laboratorije. Među-laboratorijsko ispitivanje granulometrijskog sastava, rečnog peska i šljunka iz zapadnog dela kostolačkog basena, vršeno je u skladu sa standardom SRPS U.B1.018:2005.

Uzorkovanje i priprema uzorka izvršena je saglasno tački 3.1.3, gore navedenog

standarda. Za svaku laboratoriju pripremljena su po tri reprezentativna uzorka peska i šljunka, u količini koji propisuje standard SRPS U.B1.018:2005[3]. Uzorci su na adekvatan način spakovani i isporučeni u ostale tri laboratorije.

Radi davanja uporedne analize ostvarenih rezultata, u obračun osnovnih i neo-

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phodnih parametara međulaboratorijskih ispitivanja, razmatrani su rezultati na sitima otvora, zajednička za sve laboratorije, a u skladu sa standardom.

Takođe su procenjene i varijanse ponovljivosti i obnovljivosti.

Ciljevi sprovođenja ovakvih ispitivanja, su između ostalog i :

- Provera ukupnog rada laboratorije;
- Provera osoblja laboratorija pri pojedinačnom ispitivanju;
- Uspostavljanje efikasnosti metode ispitivanja, a sve sa ciljem davanja tačnosti izlaznih rezultata korisnicima usluga laboratorija.

PRIKAZ REZULTATA MEĐULABORATORIJSKOG ISPITIVANJA

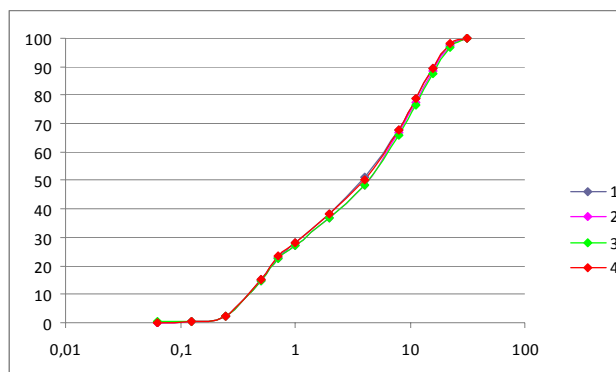
Tabela 1. Rezultati ispitivanja granulometrijskog sastava peska i šljunka [5,6]

Oznaka lab.	1			2			3			4		
Oznaka uzorka	Prva proba	Druga proba	Treća proba	Prva proba	Druga proba	Treća proba	Prva proba	Druga proba	Treća proba	Prva proba	Druga proba	Treća proba
Sita (mm)	<i>Prolaz kroz sito D(%)</i>											
0,063	0,18	0,19	0,20	0,20	0,20	0,20	0,27	0,27	0,30	0,20	0,20	0,20
0,125	0,56	0,56	0,55	0,70	0,66	0,66	0,60	0,69	0,68	0,50	0,50	0,60
0,25	2,32	2,34	2,26	2,40	2,42	2,37	2,34	2,56	2,37	2,30	2,30	2,30
0,5	14,93	15,76	15,23	14,40	14,50	14,65	14,06	15,49	14,97	14,80	15,20	15
0,71	22,36	23,77	23,21	22	22,56	22,55	21,18	23,51	22,84	22,80	23,90	23,20
1	27,08	29,16	28,27	26,60	27,69	27,45	25,78	28,34	27,66	27,30	28,50	29,10
2	36,92	39,49	38,68	36,40	37,43	37,43	34,99	38,25	37,64	36,70	38,50	39,70
4	49,45	52,03	51,75	47,50	48,08	49,74	45,92	49,70	49,67	50	50,10	50,90
8	65,38	68,78	68,97	66,70	64,71	69,10	63,03	66,18	68,41	65,20	68,70	68,70
11,2	77,61	79,22	79,41	76,60	75,87	79,48	73,83	76,31	79,35	77,90	79,40	79,80
16	89,15	89,36	89,20	87,10	90,26	87,80	84,70	88,80	88,87	89,10	89,70	89,90
22,4	97,03	97,27	98,33	97,70	97,18	96,72	96,66	96,49	97,33	97,60	98,50	98,60
31,5	100	100	100	100	100	100	100	100	100	100	100	100

Tabela 2. Srednje vrednosti ćelija

Oznaka lab. j	1	2	3	4	Suma srednjih vrednosti
Srednje vrednosti ćelija	\bar{x}_{ij}				= $\sum x_{ij}$
Sita (mm) i	\bar{X}_{i1}	\bar{X}_{i2}	\bar{X}_{i3}	\bar{X}_{i4}	$\sum \bar{x}_{ij}/4$
0,063	0,19	0,20	0,28	0,20	0,217
0,125	0,56	0,67	0,66	0,53	0,605
0,25	2,31	2,40	2,42	2,30	2,357
0,5	15,31	14,52	14,84	15	14,917
0,71	23,11	22,37	22,51	23,30	22,822
1	28,17	27,25	27,26	28,30	27,745
2	38,36	37,09	36,96	38,30	37,677
4	51,08	48,44	48,43	50,33	49,570
8	67,71	66,84	65,87	67,53	66,987
11,2	78,75	77,32	76,50	79,03	77,90
16	89,24	88,39	87,46	89,57	88,665
22,4	97,54	97,20	96,83	98,23	97,45
<i>j-oznaka lab.(1-4)</i>					
<i>i-oznaka mreže sita(1-12)</i>					

Na slici 1, grafički su prikazane srednje vrednosti granulometrijskog sastava, određene iz rezultata triju prosejavanja, za svaku od četiri ispitnih laboratorija.



Sl. 1. Srednje vrednosti granulometrijskog sastava

Tabela 3. Standardne devijacije -mere rasipanja ćelija

Oznaka lab. j	1		2		3		4		Suma kvadrata standar. devijacija
Standardne devijacije	s_{ij}								
Sita (mm) i	s_{i1}	s_{i1}^2	s_{i2}	s_{i2}^2	s_{i3}	s_{i3}^2	s_{i4}	s_{i4}^2	$\sum s_{ij}^2$
0,063	0,01	0,0001≈0	0,000	0,000	0,017	0,0003≈0	0,000	0,000	0
0,125	0,007	0,000049≈0	0,023	0,0005≈0	0,049	0,002	0,058	0,003	0,005
0,25	0,042	0,002	0,025	0,000625≈0,001	0,119	0,014	0,000	0,000	0,017
0,5	0,420	0,176	0,126	0,016	0,724	0,524	0,20	0,04	0,756
0,71	0,710	0,504	0,320	0,102	1,199	1,438	0,557	0,310	2,354
1	1,043	1,088	0,572	0,327	1,326	1,758	0,916	0,839	4,012
2	1,313	1,723	0,595	0,354	1,733	3,003	1,510	2,280	7,36
4	1,416	2,005	1,162	1,35	2,173	4,721	0,493	0,243	8,319
8	2,020	4,080	2,198	4,831	2,703	7,306	2,020	4,080	20,297
11,2	0,989	0,978	1,909	3,644	2,765	7,645	1,002	1,004	13,271
16	0,110	0,012	1,660	2,756	2,388	5,702	0,416	0,173	8,643
22,4	0,692	0,479	0,490	0,240	0,444	0,197	0,551	0,304	1,22

Napomena: Standardna devijacija treba da se izrazi jednom cifrom više, u odnosu na date rezultate u tabelama 1 i 2, te je u skladu sa tom konstatacijom izvršeno i zaokruživanje na tri decimale prikazanih rezultata u tabeli 3. (tačka 7.2.10 -SRPS ISO 5725-2).

REZULTATI COCHRANOVOG TESTA

Tabela 4. Rezultati Cochranovog testa

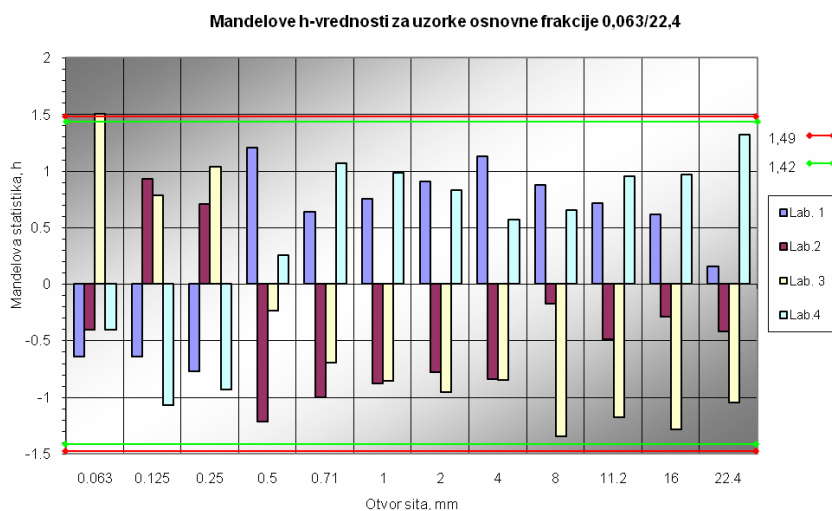
Sita (mm)	Lab.	Ispitna vrednost $S_{ij_{max}}^2$	C vrednost	Kritične vrednosti		Komentar	Ocena
				1%	5%		
0,063	/	/	/	0,864	0,768	/	/
0,125	4	0,003	0,6			$C \leq C_{tab}(5\%)$	Korektan
0,25	3	0,014	0,823*			$C(1\%) \geq C \geq (5\%)$	Zalutali (stragglers)
0,5	3	0,524	0,693			$C \leq C_{tab}(5\%)$	Korektan
0,71	3	1,438	0,611			$C \leq C_{tab}(5\%)$	Korektan
1	3	1,758	0,438			$C \leq C_{tab}(5\%)$	Korektan
2	3	3,003	0,408			$C \leq C_{tab}(5\%)$	Korektan
4	3	4,721	0,567			$C \leq C_{tab}(5\%)$	Korektan
8	3	7,306	0,360			$C \leq C_{tab}(5\%)$	Korektan
11,2	3	7,645	0,576			$C \leq C_{tab}(5\%)$	Korektan
16	3	5,702	0,66			$C \leq C_{tab}(5\%)$	Korektan
22,4	1	0,479	0,393			$C \leq C_{tab}(5\%)$	Korektan

REZULTATI MANDELOVE h I k STATISTIKE

Tabela 5. Izračunate h vrednosti

Oznaka lab. <i>j</i>	1	2	3	4	h indikator		
					1%	5%	
Sita (mm) <i>i</i>	Izračunate h vrednosti						
0,063	-0,643	-0,405	1,5** usamljena vrednost (outliers)	-0,405			
0,125	-0,643	0,929	0,786	-1,071			
0,25	-0,770	0,705	1,033	-0,934			
0,5	1,202	-1,214	-0,235	0,254			
0,71	0,640	-1,004	-0,693	1,062			
1	0,752	-0,876	-0,858	0,982			
2	0,908	-0,781	-0,953	0,828			
4	1,128	-0,844	-0,851	0,567			
8	0,871	-0,177	-1,346	0,654	1,49	1,42	
11,2	0,714	-0,487	-1,175	0,949			
16	0,612	-0,292	-1,282	0,963			
22,4	0,152	-0,422	-1,047	1,317			

Napomena: Usamljene vrednosti (outliers) nisu uzete u proračun varijansi ponovljivosti i obnovljivosti, (tačka 7.1.6 -SRPS ISO 5725-1).

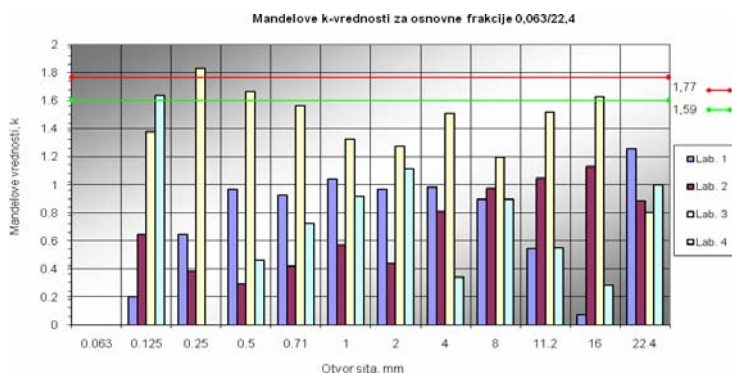


Sl. 2. Grafik h vrednosti

Tabela 6. Izračunate k vrednosti

Oznaka lab. j	1	2	3	4	k indikator		
					1%	5%	
Sita (mm) i	Izračunate k vrednosti						
0,063	0	0	0	0			
0,125	0,197	0,648	1,380	1,634* Zalutala vrednost (stragglers)			
0,25	0,646	0,385	1,831** usamljena vrednost (outliers)	0			
0,5	0,967	0,290	1,666* Zalutala vrednost (stragglers)	0,460			
0,71	0,926	0,417	1,563	0,726			
1	1,041	0,571	1,324	0,915			
2	0,968	0,439	1,277	1,113			
4	0,982	0,806	1,507	0,342			
8	0,897	0,976	1,2	0,897			
11,2	0,543	1,048	1,518	0,550			
16	0,075	1,129	1,624* Zalutala vrednost (stragglers)	0,283			
22,4	1,254	0,888	0,804	0,998			
					1,77	1,59	

Napomena: Usamljene vrednosti (outliers) nisu uzete u proračun varijansi ponovljivosti i obnovljivosti, (tačka 7.1.6 -SRPS ISO 5725-1).



Sl. 3. Grafik k vrednosti

Tabela 7. Izračunate vrednosti varijansi

Sita (mm) i	Sr ²	Sr	S _L ²	S _L	S _R ²	S _R
0,063	0,0000	0,0000	0,0374	0,1934	0,0374	0,1934
0,125	0,00125	0,0353	0,0049	0,0700	0,0061	0,0781
0,25	0,00425	0,0652	0,0016	0,0400	0,0058	0,0761
0,5	0,1890	0,4347	0,0448	0,2117	0,2338	0,4835
0,71	0,5885	0,7671	0,0081	0,0900	0,5966	0,7724
1	1,0030	1,0015	0,0000 (-0,0112)	0,0000	1,0030	1,0015
2	1,8400	1,3565	0,0000 (-0,0418)	0,0000	1,8400	1,3565
4	2,0797	1,4421	1,1069	1,0521	3,1866	1,7851
8	5,0742	2,2526	0,0000 (-0,9858)	0,0000	5,0742	2,2526
11,2	3,3177	1,8215	0,0304	0,1743	3,3481	1,8298
16	2,1607	1,4699	0,1705	0,4129	2,3312	1,5268
22,4	0,305	0,5523	0,2503	0,5002	0,5553	0,7452

Sr²-Varijansa ponovljivosti
 S_L²-Međulaboratorijska varijansa
 S_R²-Varijansa obnovljivosti

Napomena: Usled efekta slučajnosti, dobijene negativne vrednosti za S_L² smatraju se jednakim nuli (tačka 7.4.5.4- SRPS ISO 5725-2).

ZAKLJUČAK

Svrha međulaboratorijskog ispitivanja, bila je ocena preciznosti ispitne metode i ocena sposobnosti ispitnih laboratorija, u skladu sa standardima SRPS ISO 5725-2 ISO/IEC Guide 43-1:1997 i SRPS 17025 [4,7].

Nakon statističke obrade rezultata, dvema statističkim metodama, grafičkom i analitičkom, može se izvesti sledeći zaključak: Rezultat laboratorije br.3, na situ otvora 0,250 mm, nakon statističke obrade Cochranovim testom može se smatrati zalutalim, dok se ostale ispitne vrednosti iste laboratorije i laboratorije br. 1 na situ 22,4 mm i laboratorije br.4 na situ od 0,125 mm, po osnovu Cochranovog kriterijuma kritičnih vrednosti, smatraju korektnim (tabela 4).

Rezultati laboratorije br.2 su zadovoljavajući i nisu ušli u ispitni opseg, Cochranovim testom.

Prema Mandelovoj h i k statistici, u laboratoriji br. 3 utvrđen je jedan neprihvatljiv rezultat (outliers) na situ od 0,063 mm i 0,250 mm, kao i tri zalutale vrednosti prema Mandelovoj k statistici : u laboratoriji br.3 na sitima od 0,5 i 16 mm i laboratoriji br.4 na situ od 0,125 mm.

U obzir treba uzeti i moguće uticajne faktore-efekte na krajnje rezultate ispitivanja:

1. uzorkovanje (homogenost);
2. priprema uzorka (efekat homogenizacije ili izuzimanje dela uzorka);
3. efekat izvršioca;
4. uticaj transporta.

Sveobuhvatnom analizom dobijenih rezultata, može se konstantovati dobra osposobljenost laboratorija za primenu ispitne standardne metode.

LITERATURA

- [1] SRPS ISO 5725-2 Accuracy (trueness and precision) of measurement methods and results- Part 2: Basic method for the determination of repeatability and reproducibility of a standard measurement method
- [2] SRPS ISO 5725-1 Accuracy (trueness and precision) of measurement methods and results- Part 1: General principles and definitions
- [3] SRPS U.B1.018:2005 Tlo-Geomehanička ispitivanja: Određivanje granulometrijskog sastava
- [4] ISO/IEC Guide 43-1:1997 , Proficiency testing by interlaboratory comparisons- Part 1: Development and operation of proficiency testing schemes
- [5] L. Krnić, N. Peček, B. Palković- Međulaboratorijska ispitivanja granulometrijskog sastava frakcija kamenog agregata, Međunarodno savetovanje Cavtat-Dubrovnik, 3.-5. studenog 2005
- [6] D. Sekulić, A. Strineka, E. Trogrlić- Međulaboratorijsko ispitivanje granulometrijskog sastava kamenog agregata, Građevinar 60 (2008) 12, 1065-1070 7.
- [7] SRPS 17025 Opšti zahtevi za kompetentnost laboratorije za ispitivanje i laboratorije za etaloniranje

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STATISTICAL PROCESSING THE RESULTS OF INTERLABORATORY TESTING THE GRAIN-SIZE DISTRIBUTION OF SAND AND GRAVEL FROM THE WESTERN PART OF THE KOSTOLAC BASIN****

Abstract

This paper presents the results of interlaboratory testing the grain-size distribution of sand and gravel on representative samples from the site of the western part of the Kostolac Basin. The results were statistically processed by two ways: Numerical method: the Cochran test of accuracy and Graphic interpretation: the MANDEL technique of consistency in accordance with the Standard SRPS ISO 5725-2 [1,2].

The followings were calculated: repeatability variance S_r^2 ; interlaboratory variance S_L^2 and reproducibility variance S_R^2 .

Samples were submitted by sharing method to all participating laboratories.

Keywords: *statistical data processing, interlaboratory testing, grain-size distribution, standard SRPS ISO 5725-2*

1. INTRODUCTION

Four accredited laboratories participated in these testing. Interlaboratory testing of grain-size distribution of river sand and gravel from the western part of the Kostolac Basin was carried out in accordance with the Standard SRPS U.B1.018: 2005.

Sampling and sample preparation were carried out in accordance with item 3.1.3 of

the above standards. Three representative samples of sand and gravel were prepared for each laboratory in the amount prescribed by the Standard SRPS U.B1.018: 2005 [3]. The samples were properly packaged and submitted in three other laboratories.

In order to give a comparative analysis of the achieved results in calculation of basic

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and necessary parameters of interlaboratory tests, the results of sieve openings, common to all laboratories, and in accordance with the standard, were discussed

Variances of repeatability and reproducibility were also estimated.

The aims of conducting such tests, among other things, are the followings:

- Checking the total work of laboratory;
- Checking the laboratory staff at individual test;
- Establishing the efficiency of test method, with the goal of giving the accuracy of output results of laboratory services to the users.

REVIEW OF INTERLABORATORY TEST RESULTS

Table 1. Test results the grain-size distribution of sand and gravel [5,6]

Lab. designation	1			2			3			4		
Sample designation	First sample	Second sample	Third sample	First sample	Second sample	Third sample	First sample	Second sample	Third sample	First sample	Second sample	Third sample
Sieve (mm)	<i>Passage through sieve D(%)</i>											
0.063	0.18	0.19	0.20	0.20	0.20	0.20	0.27	0.27	0.30	0.20	0.20	0.20
0.125	0.56	0.56	0.55	0.70	0.66	0.66	0.60	0.69	0.68	0.50	0.50	0.60
0.25	2.32	2.34	2.26	2.40	2.42	2.37	2.34	2.56	2.37	2.30	2.30	2.30
0.5	14.93	15.76	15.23	14.40	14.50	14.65	14.06	15.49	14.97	14.80	15.20	15
0.71	22.36	23.77	23.21	22	22.56	22.55	21.18	23.51	22.84	22.80	23.90	23.20
1	27.08	29.16	28.27	26.60	27.69	27.45	25.78	28.34	27.66	27.30	28.50	29.10
2	36.92	39.49	38.68	36.40	37.43	37.43	34.99	38.25	37.64	36.70	38.50	39.70
4	49.45	52.03	51.75	47.50	48.08	49.74	45.92	49.70	49.67	50	50.10	50.90
8	65.38	68.78	68.97	66.70	64.71	69.10	63.03	66.18	68.41	65.20	68.70	68.70
11.2	77.61	79.22	79.41	76.60	75.87	79.48	73.83	76.31	79.35	77.90	79.40	79.80
16	89.15	89.36	89.20	87.10	90.26	87.80	84.70	88.80	88.87	89.10	89.70	89.90
22.4	97.03	97.27	98.33	97.70	97.18	96.72	96.66	96.49	97.33	97.60	98.50	98.60
31.5	100	100	100	100	100	100	100	100	100	100	100	100

Table 2. Average values of cells

Lab designation <i>j</i>	1	2	3	4	Sum of average values
Average values of cells	\bar{x}_{ij}				$=$
Sieve (mm) <i>i</i>	\bar{X}_{i1}	\bar{X}_{i2}	\bar{X}_{i3}	\bar{X}_{i4}	$\Sigma \bar{x}_{ij}/4$
0.063	0.19	0.20	0.28	0.20	0.217
0.125	0.56	0.67	0.66	0.53	0.605
0.25	2.31	2.40	2.42	2.30	2.357
0.5	15.31	14.52	14.84	15	14.917
0.71	23.11	22.37	22.51	23.30	22.822
1	28.17	27.25	27.26	28.30	27.745
2	38.36	37.09	36.96	38.30	37.677
4	51.08	48.44	48.43	50.33	49.570
8	67.71	66.84	65.87	67.53	66.987
11.2	78.75	77.32	76.50	79.03	77.90
16	89.24	88.39	87.46	89.57	88.665
22.4	97.54	97.20	96.83	98.23	97.45

j- lab designation(1-4)
i-mesh size designation(1-12)

Figure 1 graphically shows the average values of grain-size distribution, determined from the results of three screening, for each of the four testing laboratories.

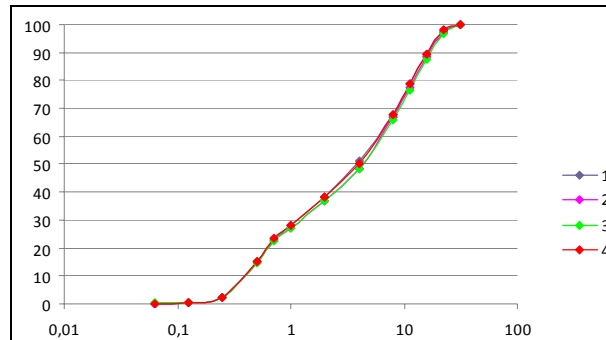


Fig. 1. Average values of grain-size distribution

Table 3. Standard deviations – measures of cell dissipations

Lab designation <i>f</i>	1		2		3		4		Sum of squares of standard deviations $\sum S_{ij}^2$
Standard deviations	<i>s_{ij}</i>								
Sieve (mm) <i>i</i>	<i>S_{i1}</i>	<i>S_{i1}²</i>	<i>S_{i2}</i>	<i>S_{i2}²</i>	<i>S_{i3}</i>	<i>S_{i3}²</i>	<i>S_{i4}</i>	<i>S_{i4}²</i>	
0.063	0.01	0.0001≈0	0.000	0.000	0.017	0.0003≈0	0.000	0.000	0
0.125	0.007	0.000049≈0	0.023	0.0005≈0	0.049	0.002	0.058	0.003	0.005
0.25	0.042	0.002	0.025	0.000625≈0.001	0.119	0.014	0.000	0.000	0.017
0.5	0.420	0.176	0.126	0.016	0.724	0.524	0.20	0.04	0.756
0.71	0.710	0.504	0.320	0.102	1.199	1.438	0.557	0.310	2.354
1	1.043	1.088	0.572	0.327	1.326	1.758	0.916	0.839	4.012
2	1.313	1.723	0.595	0.354	1.733	3.003	1.510	2.280	7.36
4	1.416	2.005	1.162	1.35	2.173	4.721	0.493	0.243	8.319
8	2.020	4.080	2.198	4.831	2.703	7.306	2.020	4.080	20.297
11.2	0.989	0.978	1.909	3.644	2.765	7.645	1.002	1.004	13.271
16	0.110	0.012	1.660	2.756	2.388	5.702	0.416	0.173	8.643
22.4	0.692	0.479	0.490	0.240	0.444	0.197	0.551	0.304	1.22

Note: Standard deviation should be expressed by one digit more, compared to the results given in Tables 1 and 2, and in accordance with this statement, a rounding was made to three decimals of shown results in Table 3 (item 7.2.10 -SRPS ISO 5725-2).

THE COCHRAN TEST RESULTS

Table 4. The Cochran test results

Sieve (mm)	Lab	Test value $S_{ij_{max}}^2$	C value	Critical values		Comment	Evaluation
				1%	5%		
0.063	/	/	/	0.864	0.768	/	/
0.125	4	0.003	0.6			$C \leq C_{tab}(5\%)$	Correct
0.25	3	0.014	0.823*			$C(1\%) \geq C(5\%)$	Stragglers
0.5	3	0.524	0.693			$C \leq C_{tab}(5\%)$	Correct
0.71	3	1.438	0.611			$C \leq C_{tab}(5\%)$	Correct
1	3	1.758	0.438			$C \leq C_{tab}(5\%)$	Correct
2	3	3.003	0.408			$C \leq C_{tab}(5\%)$	Correct
4	3	4.721	0.567			$C \leq C_{tab}(5\%)$	Correct
8	3	7.306	0.360			$C \leq C_{tab}(5\%)$	Correct
11.2	3	7.645	0.576			$C \leq C_{tab}(5\%)$	Correct
16	3	5.702	0.66			$C \leq C_{tab}(5\%)$	Correct
22.4	1	0.479	0.393			$C \leq C_{tab}(5\%)$	Correct

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Table 5. Calculated h values

Lab designation <i>j</i>	1	2	3	4	h indicator	
					1%	5%
Sieve (mm) <i>i</i>	Calculated h values				1.49	1.42
0.063	-0.643	-0.405	1.5** Outliers	-0.405		
0.125	-0.643	0.929	0.786	-1.071		
0.25	-0.770	0.705	1.033	-0.934		
0.5	1.202	-1.214	-0.235	0.254		
0.71	0.640	-1.004	-0.693	1.062		
1	0.752	-0.876	-0.858	0.982		
2	0.908	-0.781	-0.953	0.828		
4	1.128	-0.844	-0.851	0.567		
8	0.871	-0.177	-1.346	0.654		
11.2	0.714	-0.487	-1.175	0.949		
16	0.612	-0.292	-1.282	0.963		
22.4	0.152	-0.422	-1.047	1.317		

Note: The outliers were not included in the calculation of repeatability and reproducibility variances, (item 7.1.6 -SRPS ISO 5725-1).

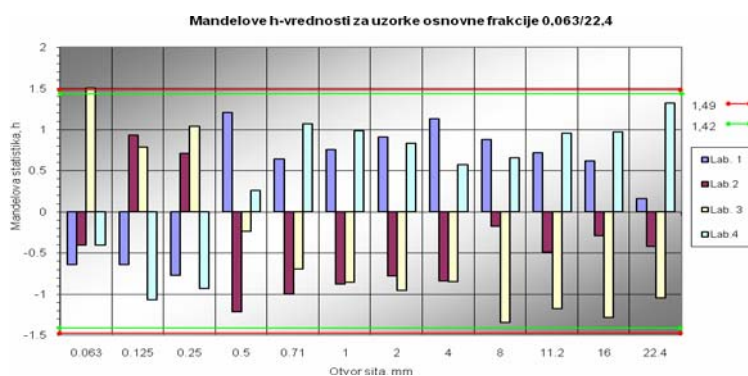


Fig. 2. Graph of h values

Table 6. Calculated k values

Lab designation <i>j</i>	1	2	3	4	k indicator	
					1%	5%
Sieve (mm) <i>i</i>	Calculated k values				1.77	1.59
0.063	0	0	0	0		
0.125	0.197	0.648	1.380	1.634* Stragglers		
0.25	0.646	0.385	1.831** Outliers	0		
0.5	0.967	0.290	1.666* Stragglers	0.460		
0.71	0.926	0.417	1.563	0.726		
1	1.041	0.571	1.324	0.915		
2	0.968	0.439	1.277	1.113		
4	0.982	0.806	1.507	0.342		
8	0.897	0.976	1.2	0.897		
11.2	0.543	1.048	1.518	0.550		
16	0.075	1.129	1.624* Stragglers	0.283		
22.4	1.254	0.888	0.804	0.998		

Note: The outliers were not included in the calculation of repeatability and reproducibility variances, (item 7.1.6 -SRPS ISO 5725-1).

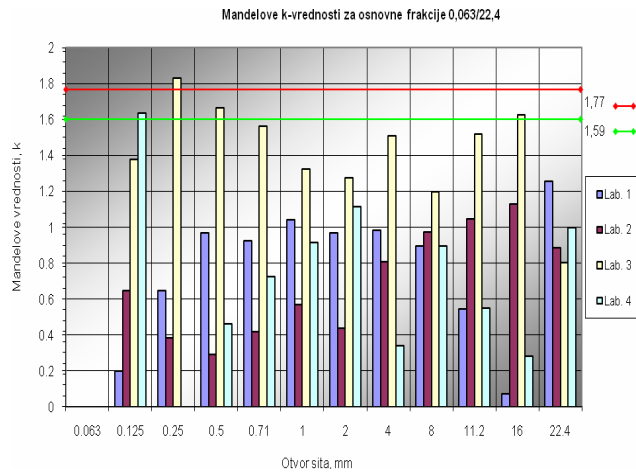


Fig. 3. Graph of k values

Table 7. Calculated values of variances

Sieve (mm) i	S_r^2	S_r	S_L^2	S_L	S_R^2	S_R
0.063	0.0000	0.0000	0.0374	0.1934	0.0374	0.1934
0.125	0.00125	0.0353	0.0049	0.0700	0.0061	0.0781
0.25	0.00425	0.0652	0.0016	0.0400	0.0058	0.0761
0.5	0.1890	0.4347	0.0448	0.2117	0.2338	0.4835
0.71	0.5885	0.7671	0.0081	0.0900	0.5966	0.7724
1	1.0030	1.0015	0.0000 (-0.0112)	0.0000	1.0030	1.0015
2	1.8400	1.3565	0.0000 (-0.0418)	0.0000	1.8400	1.3565
4	2.0797	1.4421	1.1069	1.0521	3.1866	1.7851
8	5.0742	2.2526	0.0000 (-0.9858)	0.0000	5.0742	2.2526
11.2	3.3177	1.8215	0.0304	0.1743	3.3481	1.8298
16	2.1607	1.4699	0.1705	0.4129	2.3312	1.5268
22.4	0.305	0.5523	0.2503	0.5002	0.5553	0.7452
S_r^2-Repeatability variance						
S_L^2-Interlaboratory variance						
S_R^2- Reproducibility variance						

Note: Due to the effect randomness, the obtained negative values for S_L are considered equal to zero (item 7.4.5.4-ISO 5725-2).

CONCLUSION

The purpose of interlaboratory testing was evaluation the test method precision and evaluation the capabilities of testing laboratories, in accordance with the Stan-

dards SRPS ISO 5725-2 ISO/IEC Guide 43-1:1997 i SRPS 17025 [4,7].

After statistical processing the results using two statistical methods, graphical

and analytical, the following conclusion can be made: the result of laboratory no.3, on the sieve of mesh size 0.250 mm, after statistical processing by the Cochran test can be considered as strayed, until all other test values of the same laboratory and laboratory no. 1 on the sieve of 22.4 mm and laboratory no. 4 on the sieve of 0.125 mm, based on the Cochran criteria of critical values, are considered as correct (Table 4).

The results of laboratory no.2 were satisfactory and did not include into test range by the Cochran test.

According to the Mandel h and k in laboratory no. 3, an unacceptable result (outliers) was determined on the sieve of 0.063 mm and 0.250 mm, and three stray values according to the Mandel k statistics: in the laboratory no.3 on the sieves of 0.5 and 16 mm and laboratory no. 4 on the sieve 0.125 mm.

Possible influencing factors-effects on the final results of testing should be also taken into consideration:

- sample (homogeneity);
- sample preparation (excluding the effect of homogenization or excluding a part of sample);
- effect of performer,
- impact of transport.

By comprehensive analysis the results, the good capability of laboratories can be stated for the use of standard test method.

REFERENCES

- [1] SRPS ISO 5725-2 Accuracy (Trueness and Precision) of Measurement Methods and Results- Part 2: Basic Method for Determination of Repeatability and Reproducibility of a Standard Measurement Method;
- [2] SRPS ISO 5725-1 Accuracy (Trueness and Precision) of Measurement Methods and Results - Part 1: General Principles and Definitions;
- [3] SRPS U.B1.018:2005 Soil – Geomechanical Testing: Determination of Grain-Size Distribution (in Serbian);
- [4] ISO/IEC Guide 43-1:1997, Proficiency Testing by Interlaboratory Comparisons - Part 1: Development and Operation of Proficiency Testing Schemes;
- [5] L. Krnić, N. Peček, B. Palković, Interlaboratory Testing of Grain-Size Distribution of Stone Aggregate Fractions, International Conference Cavtat-Dubrovnik, 3 to 5 November, 2005 (in Serbian);
- [6] D. Sekulić, A. Strineka, E. Trogrlić, Interlaboratory Testing of Grain-Size Distribution of Stone Aggregate, *Gradjevinar* 60 (2008) 12, 1065-1070 (in Serbian);
- [7] SRPS 17025 General Requirements for Competence of Testing Laboratory and Laboratory for Standardization (in Serbian).