Univerza
v Ljubljani

Fakulteta
za gradbeništvo
in geodezijo

Katedra za mehaniko tal z laboratorijem

Jamova c. 2,p.p.3422
1000 Ljubljana, Slovenija
telefon 01 4768 500
faks01 4250 681
e-mail bmajes@fgg.uni-lj.si

REPORT ON

Usage of Andreas dynamic load bearing capacity and compactness deflectometer**)**

1 INTRODUCTION

In report next definitions could be found:
E_d – dynamic layer modulus (MPa) for Andreas dynamic load bearing capacity and compactness deflectometer (further Andreas BC plate)
T_{rE} – relative field compactness degree (%) for Andreas BC plate
E_{vib} – vibratory modulus for continues controlled compaction (CCC) vibratory roller.
E_{vd} – dynamic deformation modulus for ZORN light falling weight deflectometer (LFWD) (ZFG-01)

1.1 Principles of measurements

Andreas BC plate measures dynamic layer modulus E_d from settlements s in 4th to 6th drop in the same way as ZORN LFWD (see equation 1). Relative field compactness degree is calculated from development of settlements through drops.

$$E_d = \frac{c}{s}(1-\mu^2)\,p_{din} \cdot r \qquad (1)$$

Where is: c – Bossinesq plate multiplier (stiffness); s – plate settlement, μ- Poisson coefficient; p_{din} – dynamic load; r – plate radius

From equation 1 high influence of Poisson coefficient and Bossinesq plate multiplier on dynamic layer modulus can be observed. In our measurements we used Poisson coefficient μ=0,5 and Bossinesq plate multiplier c=2.

CCC measures vibratory modulus Evib. Evib increases through roller passes and at some point it reach its maximum value. Further compaction is then unreasonable due to no increase of layer stiffness.

Evib can be compared with dynamic deformation modulus Evd, so dynamic layer modulus Ed can be compared with Evib due to the same measurement technique. Evib is also measurement of relative compaction (it tells you when to stop compacting), so correlations with relative field compactness will be made.

1.2 Measured materials

Measurements were obtained on 3 different materials: crushed marl, gravel from NE Slovenia, and mixture of flay ash, gypsum and scoria.

Measurements with Andreas dynamic load bearing capacity and compactness deflectometer (Andreas BC plate) were compared with measurements done with ZORN light weight dynamic plate (ZFG-01) (E_{vd}) and CCC vibratory roller (Bomag BW 216 (E_{vib})).

2 RESULTS

2.1 Mixture of fly ash, gypsum and scoria

Measurements were done on waste disposal Prapretno. Test field from 29.6.2006 showed on difficulties with compaction. Material could be compacted only to 86-95% of standard Proctor density. This value is about 92% of relative compaction (which is measured by Andreas BC plate).

In table 1 are measured results of E_d and T_{rE} obtained with Andreas BC plate. High values of relative compaction could be seen. In this case Andreas BC plate shows on unreasonableness of further compaction.

Table 1: Measurements on waste disposal Prapretno

E_d (MPa)	T_{rE} (%)
22.6	97.8
29.0	99.2
26.0	98.3

2.2 Hydro plant Avče

Dam of hydro plant Avče is build from soft rock – Flysch (marl). Due to poor granular size (almost no sand and grains up to 40cm) high differences in measurement were expected. The measurements spots were located at homogeneous area.

In table 2 and 3 are measurements of E_d, T_{rE} (Andreas BC plate), E_{vd} (ZORN) and local E_{vib} from CCC roller.

Table 2: Measurements at HP Avče on 21.4.2007.

i	linija	prehod	lokacija (m)	E_{vib}	E_{vd} (MPa)		E_d (MPa)		T_{rE} (%)	
					povp.	st. dev.	povp.	st. dev.	povp.	st. dev.
1	1	1	4	87	36.2	2.9	55.7	1.7	90.9	3.3
2	1	3	3	97	44.5	5.0	75.1	3.2	93.7	2.8
3	1	3	6	97	47.2	7.3	78.5	4.5	94.9	0.8
4	1	5	4	92	47.3	9.5	73.3	9.1	94.2	1.3
5	2	1	4	92	39.6	5.0	65.8	6.1	88.8	1.8
6	2	3	3	100	47.1	0.9	85.3	18.7	95.9	1.9
7	3	1	5	82	33.9	6.1	52.5	22.0	90.2	6.4

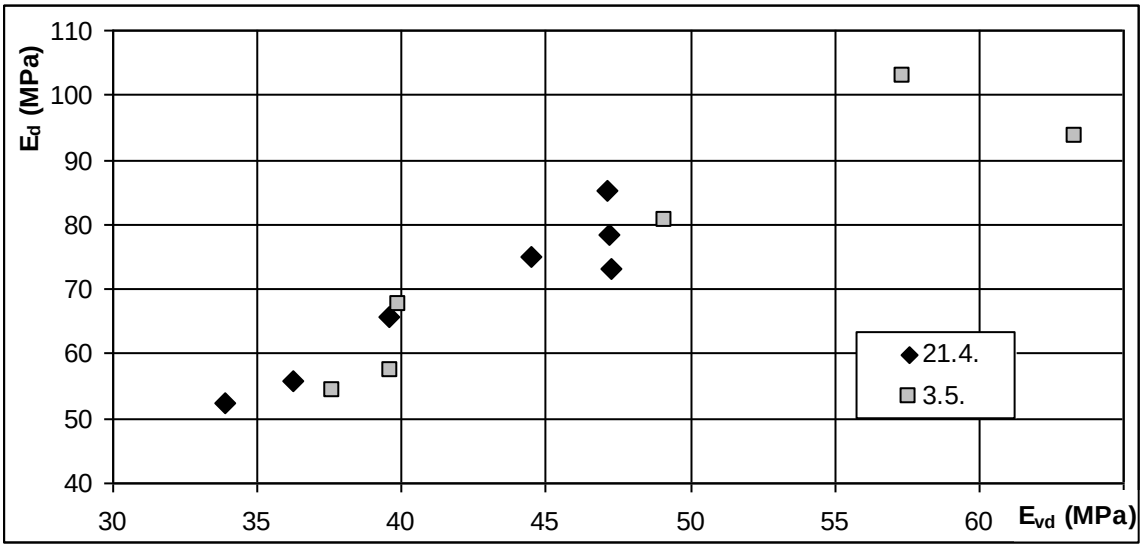
Linija – line number
Prehod – passage number
Lokacija – location from start (m)

Table 3: Measurements at HP Avče on 3.5.2007.

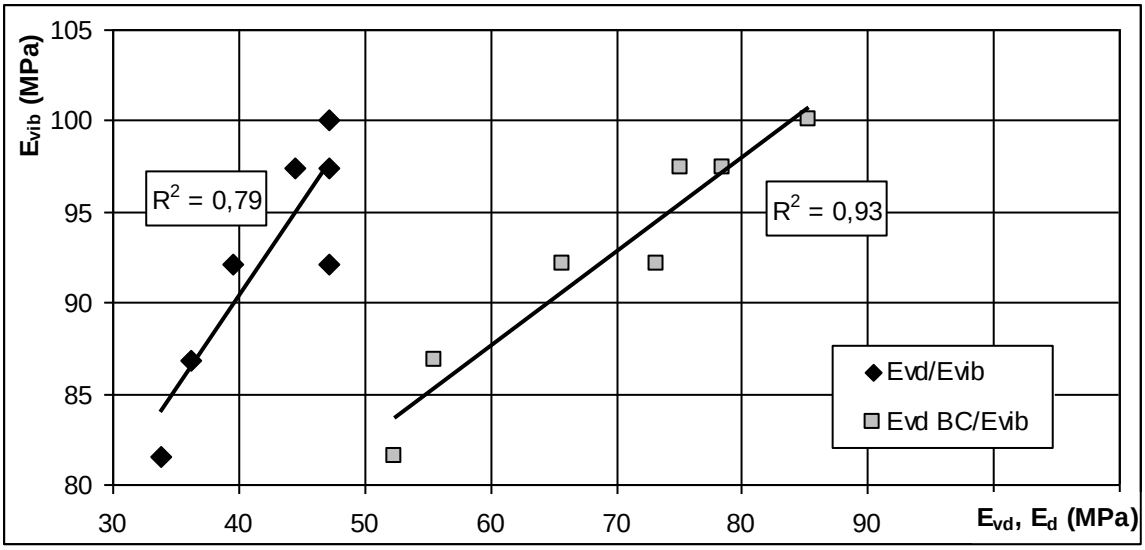
i	linija	prehod	lokacija (m)	E_{vib}	E_{vd} (MPa)		E_d (MPa)		T_{rE} (%)	
					povp.	st. dev.	povp.	st. dev.	povp.	st. dev.
0	2	0	16				58.3	11.5	85.4	9.3
1	1	1	7	75	39.7	5.9	57.3	11.7	92.0	2.8
2	1	1	13	35	37.6	6.9	54.4	9.5	89.7	3.2
3	1	1	21	93	39.9	2.3	67.7	8.5	93.5	1.7
6	1	3	16	165	63.3	9.7	93.6	14.3	96.4	1.5
7	1	3	22	170	49.1	5.8	80.6	9.8	94.1	2.6
9	1	6	17	203	57.4	7.1	102.8	8.2	96.7	1.1

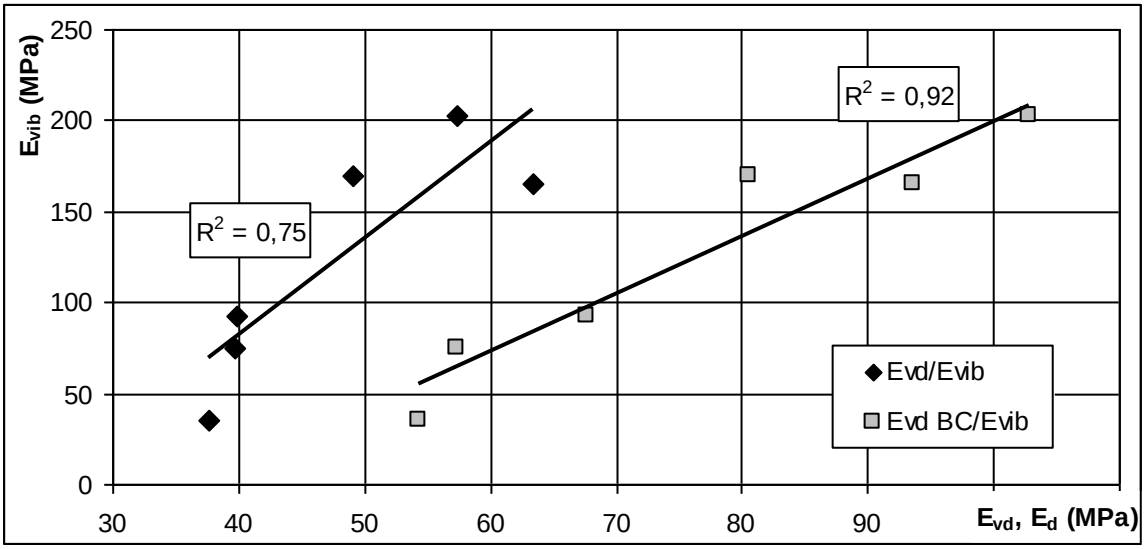
Findings:

- Ed and Evd do not have the same values, but correlation between them is good (Picture 1)
- Ed gives better correlation with Evib then Evd. Maybe due to better sensor
- TrE and Evib stop rising at the same number passages

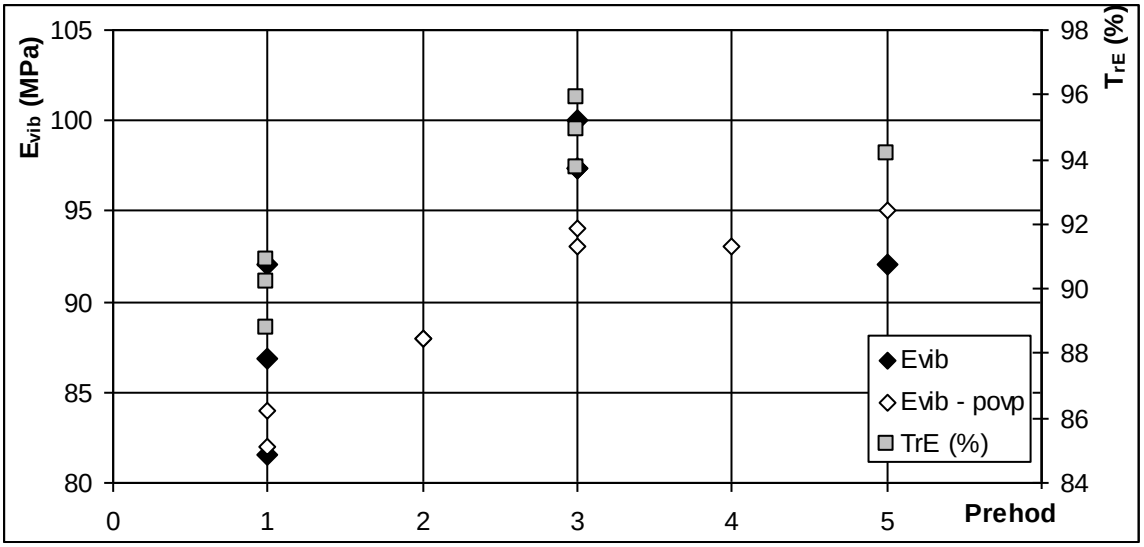


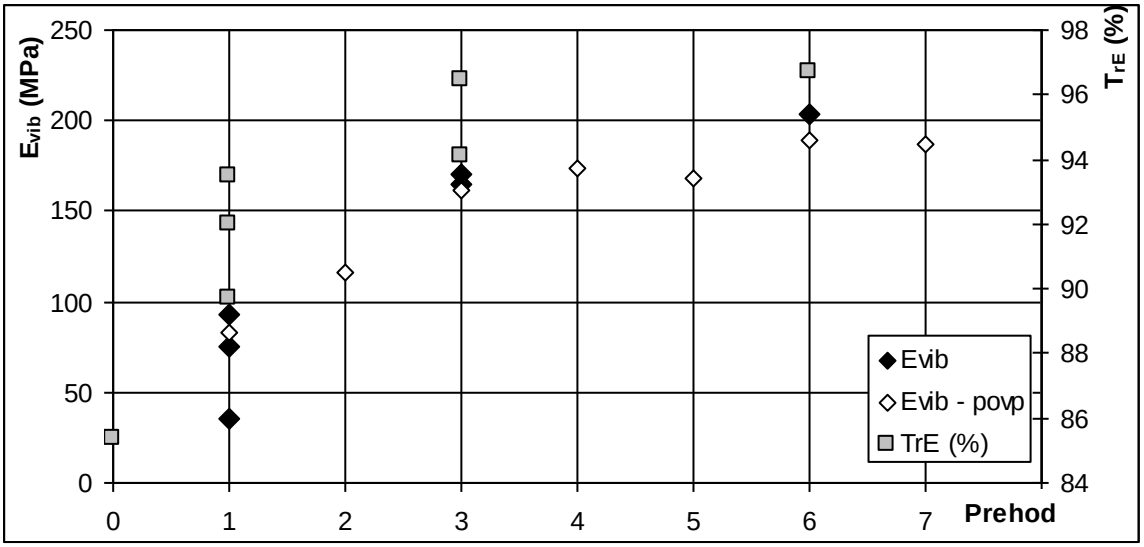
Picture 1: Comparison between Ed and Evd





Picture 2: Comparison between Ed - Evib and Evd - Evd for two different test fields. Better correlation between Ed and Evib culd be seen.





Picture 3: Correlations between Evib and TrE give same shapes. The same number of passes is seen from mean Evib and TrE.

2.3 Construction site near Dolga vas (Pomurje)

Motorway near Dolga vas is constructed from local gravel. This gravel is problematic for compaction due to its grain size distribution. Evd values measured at this location were low maybe due to grains translation under plate.

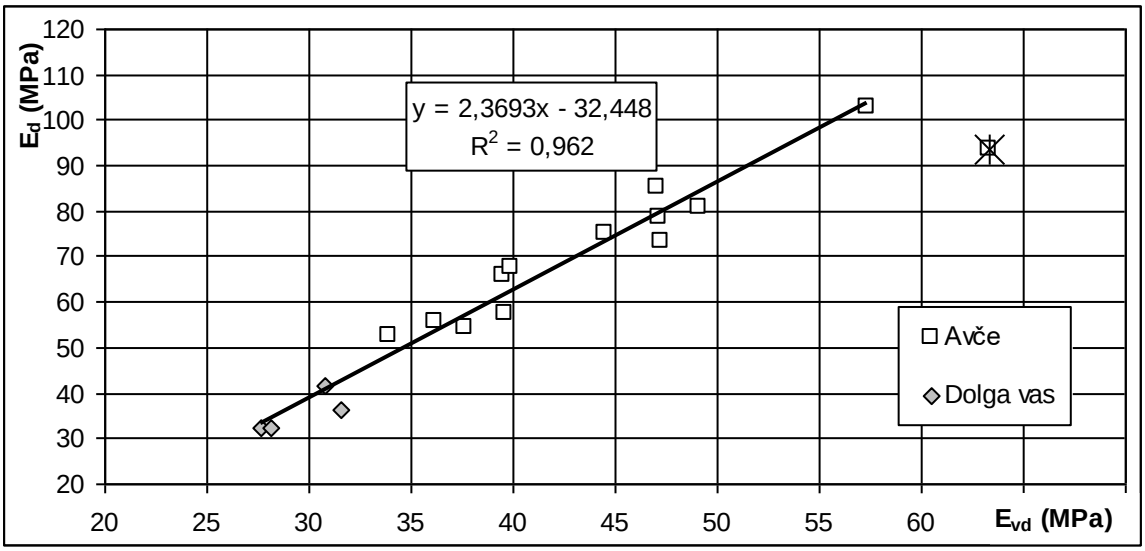
Due to small number of test no correlation can be drawn. At this point problem with Andreas BC plate occurred

Table 4: Measurements at motorway Dolga vas.

i	linija	prehod	lokacija (m)	E_{vib}	E_{vd} (MPa)		E_d (MPa)		T_{rE} (%)	
					povp.	st. dev.	povp.	st. dev.	povp.	st. dev.
1	1	0	10	0	31.5	1.9	36.3	6.0	87.9	1.6
2	1	0	20	0	27.7	3.4	32.1	4.6	85.8	3.7
3	1	1	5	61	30.8	4.5	41.5	7.3	85.4	4.8
4	1	1	22.5	32	28.2	0.6	32.4	0.8	88.5	0.6

3 CONCLUSIONS

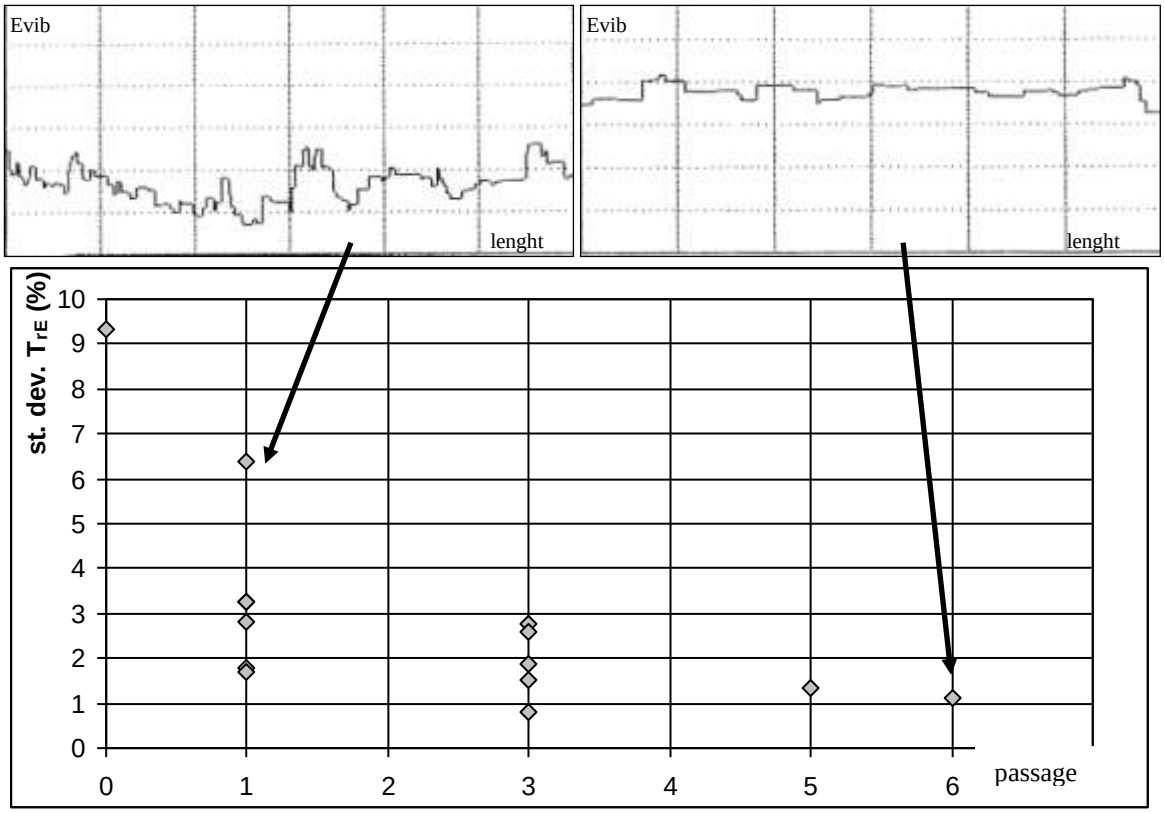
Ed and Evd do not have the same values, but correlation between them is good (picture 4)



Picture 4: Measurement of Evd and Ed on Avče and at Dolga vas. Crossed measurement is not used for calculation of trend line.

- TrE and Evib show the same level of compaction. At the same number of passages the stop rising.

- After first passage there are high differences between TrE values. But these differences get smaller after each passage (Picture 5). The same trend shows CCC roller. Due to the differences 3 or more relative compaction measurements should be done at the same spot.



Picture 5: Standard deviation of TrE with number of passages. Same trend is seen in Evib line.

During testing some problems occurred:

- Keys sometimes do not work.
- Sound for drop can not be heard in noise of mechanization.
- Connectors can be taken in pieces.
- Connecting weight to release mechanism is recognized as drop.
- Release and safety mechanism are not strong enough.

Measurements at HP Avče

21. 4.

i	linija	prehod	lokacija (m)	E_{vib} (MPa)	E_{vd} (MPa)					
					meritve				povp.	st. dev.
1	1	1	4	87	33,1	38,7	38,6	34,5	36,2	2,9
2	1	3	3	97	47,3	37,6	44,2	48,9	44,5	5,0
3	1	3	6	97	47,5	39,1	45,4	56,8	47,2	7,3
4	1	5	4	92	50,2	52,8	33,1	52,9	47,3	9,5
5	2	1	4	92	37,5	46,7	38,8	35,2	39,6	5,0
6	2	3	3	100	47,4	48,3	46,5	46,2	47,1	0,9
7	3	1	5	82	33,1	31,4	28,4	42,6	33,9	6,1
i	linija	prehod	lokacija (m)	E_{vib} (MPa)	E_d (MPa)					
					meritve				povp.	st. dev.
1	1	1	4	87	53,2	56,7	56,7	56,0	55,7	1,7
2	1	3	3	97	73,3	78,8	73,3		75,1	3,2
3	1	3	6	97	73,3	81,8	80,3		78,5	4,5
4	1	5	4	92	81,8	63,5	67,5	80,3	73,3	9,1
5	2	1	4	92	70,9	67,5	59,1		65,8	6,1
6	2	3	3	100	80,3	106,0	69,7		85,3	18,7
7	3	1	5	82	35,2	31,7	70,9	72,1	52,5	22,0
i	linija	prehod	lokacija (m)	E_{vib} (MPa)	T_{rE} (%)					
					meritve				povp.	st. dev.
1	1	1	4	87	93,0	92,0	86,0	92,5	90,9	3,3
2	1	3	3	97	91,0	92,3	94,2	97,4	93,7	2,8
3	1	3	6	97	94,8	94,2	95,8		94,9	0,8
4	1	5	4	92	95,5	92,5	93,7	94,9	94,2	1,3
5	2	1	4	92	87,5	90,0			88,8	1,8
6	2	3	3	100	94,6	98,0	95,0		95,9	1,9
7	3	1	5	82	84,1	85,2	96,0	95,4	90,2	6,4

3. 5.

i	linija	prehod	lokacija (m)	E_{vib} (MPa)	E_{vd} (MPa)							
					meritve						povp.	st. dev.
1	1	1	7	75	48,4	37,8	36,9	35,5			39,7	5,9
2	1	1	13	35	34,6	30,8	47,0	38,1			37,6	6,9
3	1	1	21	93	36,7	41,0	42,0	40,0			39,9	2,3
6	1	3	16	165	73,5	47,5	56,1	66,2	66,2	70,5	63,3	9,7
7	1	3	22	170	57,3	43,6	52,0	43,8	48,9		49,1	5,8
9	1	6	17	203	50,6	67,0	54,0	58,0			57,4	7,1
i	linija	prehod	lokacija (m)	E_{vib} (MPa)	E_d (MPa)							
					meritve						povp.	st. dev.
1	1	1	7	75	62,6	40,5	70,7	61,6	51,2		57,3	11,7
2	1	1	13	35	68,6	50		50	48,9		54,4	9,5
3	1	1	21	93	72,1	72,1	52,5	70,9	70,9		67,7	8,5
4	1	3	16	165	74,6	109,2	94,5	96,2			93,6	14,3
5	1	3	22	170	68,6	78,8	85,1	94,5	76		80,6	9,8
6	1	6	17	203	111,9	96,7	109,1	92,5	103,8		102,8	8,2
7	1	0			59,9	51,9	42,1	66,5	70,9		58,3	11,5
i	linija	prehod	lokacija (m)	E_{vib} (MPa)	T_{rE} (%)							
					meritve						povp.	st. dev.
1	1	1	7	75	93,1	94,0	93,7	92,1	87,2		92,0	2,8
2	1	1	13	35	91,0	93,4	86,0	91,5	86,6		89,7	3,2
3	1	1	21	93		92,7	91,5	94,5	95,2		93,5	1,7
4	1	3	16	165	94,7	97,2	98,3	95,0	97,0		96,4	1,5
5	1	3	22	170	91,0	92,8	94,7	98,0	93,9		94,1	2,6
6	1	6	17	203	96,7	96,1	97,7	95,2	97,8		96,7	1,1
7	2	0	16		69,5	90,9	84,8	92,4	89,2		85,4	9,3

Measurements at motorway near Dolga vas

i	linija	prehod	lokacija (m)	E_{vib} (MPa)	E_{vd} (MPa)					
					meritve				povp.	st. dev.
1	1	0	10	0	29,5	32,1	30,7	33,8	31,5	1,9
2	1	0	20	0	30,7	27,4	29,5	23,0	27,7	3,4
3	1	1	5	61	27,4	28,0	30,4	37,2	30,8	4,5
4	1	1	22,5	32	28,4	28,3	27,3	28,6	28,2	0,6
i	**linija**	**prehod**	**lokacija (m)**	**E_{vib} (MPa)**	**E_d (MPa)**					
					meritve				povp.	st. dev.
1	1	0	10	0	35,2	30,8	34,3	44,8	36,3	6,0
2	1	0	20	0	34,6	34,6	34,0	25,3	32,1	4,6
3	1	1	5	61	40,5	35,2	38,3	51,9	41,5	7,3
4	1	1	22,5	32	31,5	32,7	33,0		32,4	0,8
i	**linija**	**prehod**	**lokacija (m)**	**E_{vib} (MPa)**	**T_{rE} (%)**					
					meritve				povp.	st. dev.
1	1	0	10	0	86,0	87,3	88,8	89,5	87,9	1,6
2	1	0	20	0	83,6	82,2	90,6	86,9	85,8	3,7
3	1	1	5	61	80,3	87,6	82,8	90,9	85,4	4,8
4	1	1	22,5	32	87,8	89,0	88,6		88,5	0,6