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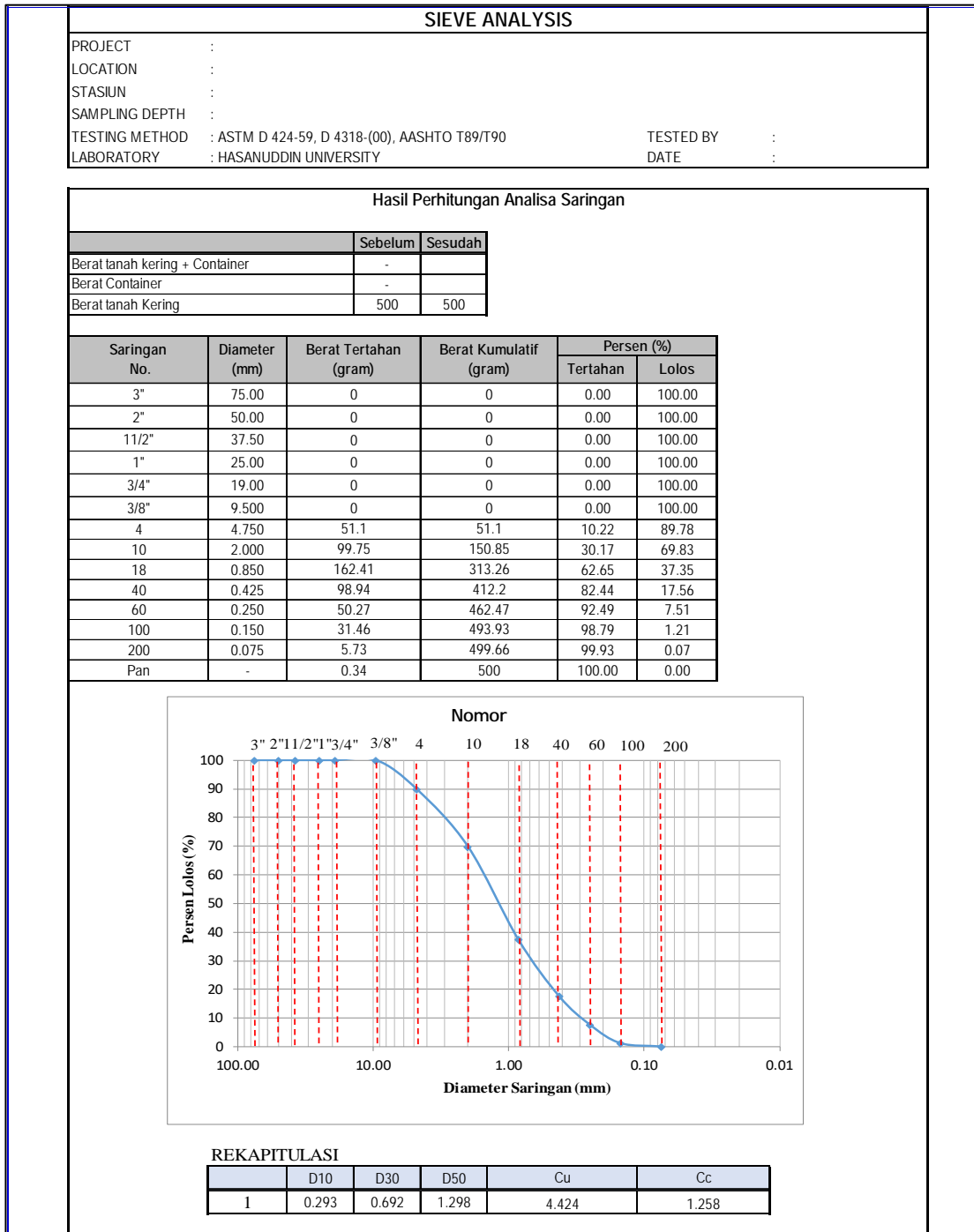
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## LAMPIRAN

### Lampiran 1. Data hasil uji laboratorium Gradasi material sedimen dasar







Lampiran 4. Perhitungan kecepatan aliran pada kondisi kedalaman normal

Data ukur			Metode Logaritmik Clautser's (Dasar Licin)							
$X_4 = 4.50 \text{ m}$			$\frac{u_z}{u_*} = \frac{1}{\kappa} \ln \left( \frac{y}{k_s} \right) + C$							
$z \text{ (Cm)}$	$D \text{ (Cm)}$	$U \text{ (Cm)}$	$z/D$	$k_s$	$\ln(z/k_s)$	$K$	$\tan \alpha$	$u^*$	$C$	$uz$
0.001		0.000	0.000		-4.700					10.475
0.002		0.000	0.000		-4.007					12.208
0.003		0.000	0.000		-3.602					13.221
0.005		0.000	0.000		-3.091					14.498
0.010		0.000	0.001		-2.398					16.231
0.030		0.000	0.003		-1.299					18.978
0.070		0.000	0.006		-0.452					21.096
0.100		0.000	0.009		-0.095					21.988
0.300		15.610	0.028		1.003					24.734
0.600		19.800	0.055		1.696					26.467
0.900	10.900	21.320	0.083	0.110	2.102	0.400	5.333	2.133	10.419	27.481
1.200		23.920	0.110		2.390					28.200
1.500		24.220	0.138		2.613					28.758
1.800		25.050	0.165		2.795					29.214
2.100		25.850	0.193		2.949					29.599
2.500		26.650	0.229		3.124					30.035
3.500		27.240	0.321		3.460					30.876
4.500		27.430	0.413		3.711					31.504
5.500		27.820	0.505		3.912					32.006
6.500		28.380	0.596		4.079					32.424
7.500		30.020	0.688		4.222					32.781
8.500		30.540	0.780		4.347					33.094

Lampiran 5. Perhitungan kecepatan aliran kondisi kedalaman kritis

Data ukur LQ3S0			Metode Logaritmik Von-Karman (Butir Pasir)							
$X_4 = 4.50 \text{ m}$			$\frac{u_z}{u_*} = \frac{1}{\kappa} \ln \left( \frac{y}{k_s} \right) + C$							
$z \text{ (Cm)}$	$D \text{ (Cm)}$	$U \text{ (Cm)}$	$z/D$	$k_s$	$\ln$	$K$	$\tan \alpha$	$u_*$	$C$	$uz$
0.001		0.000	0.000		-4.508					9.771
0.002		0.000	0.000		-3.814					11.504
0.003		0.000	0.000		-3.409					12.518
0.005		0.000	0.001		-2.898					13.795
0.010		0.000	0.001		-2.205					15.528
0.030		0.000	0.003		-1.106					18.274
0.070		0.000	0.007		-0.259					20.392
0.100		0.000	0.011		0.098					21.284
0.300		14.560	0.032		1.196					24.031
0.600		17.703	0.063		1.889					25.764
0.900	9.500	19.349	0.095	0.010	2.295	0.400	6.025	2.410	8.730	26.777
1.200		21.022	0.126		2.583					27.496
1.500		23.925	0.158		2.806					28.054
1.800		25.795	0.189		2.988					28.510
2.100		25.919	0.221		3.142					28.895
2.500		25.219	0.263		3.317					29.331
3.500		26.046	0.368		3.653					30.172
4.500		27.249	0.474		3.904					30.801
5.500		27.650	0.579		4.105					31.302
6.500		28.240	0.684		4.272					31.720
7.500		29.938	0.789		4.415					32.078
8.500		29.480	0.895		4.540					32.391



Lampiran 6. Perhitungan kecepatan aliran pada MP<sub>1</sub> (x = 3,75 m)

Data Ukur MP1			Cari u* (Logaritmik Clautser)							
X = 3.75			$\frac{u_z}{u_*} = \frac{1}{\kappa} \ln\left(\frac{y}{k_s}\right) + C$							
z	D	U	z/D	ks	ln(z/ks)	K	tan α	u*	C	u <sub>z</sub>
0.50	11.20	19.54	0.04	0.110	1.514	0.4	3.044	1.217	18.225	25.972
1.00	11.20	21.92	0.09		2.207					27.705
1.50	11.20	27.38	0.13		2.613					28.719
2.00	11.20	29.31	0.18		2.900					29.438
3.00	11.20	22.95	0.27		3.306					30.452
4.00	11.20	19.77	0.36		3.594					31.171
5.00	11.20	27.68	0.45		3.817					31.729
6.00	11.20	20.55	0.54		3.999					32.185
7.00	11.20	29.04	0.63		4.153					32.570
8.00	11.20	23.63	0.71		4.287					32.904
9.00	11.20	22.37	0.80	4.404	33.198					

Lampiran 7. Pengukuran kedalaman gerusan tanpa model SPE

Waktu (Menit)	Kedalaman Gerusan Lokal (d <sub>s</sub> (cm))					
	Titik Pengamatan					
	1	2	3	4	5	6
0	0.00	0.00	0.00	0.00	0.00	0.00
3	0.53	-1.57	-4.17	-3.77	-0.77	0.13
5	0.43	-2.17	-4.97	-3.47	-1.37	0.43
7	-0.57	-2.87	-4.87	-4.27	-1.57	0.33
10	-0.67	-2.87	-4.67	-4.37	-2.87	0.43
15	-0.57	-3.87	-5.27	-5.37	-4.57	0.53
20	-0.30	-3.77	-5.57	-5.07	-4.52	0.58
30	-0.03	-3.67	-5.87	-4.77	-4.47	0.63
40	-0.16	-3.87	-5.90	-5.00	-4.84	0.66
50	-0.30	-4.07	-5.94	-5.24	-5.20	0.70
60	-0.43	-4.27	-5.97	-5.47	-5.57	0.73
70	-0.46	-4.30	-6.09	-5.64	-5.49	0.54
80	-0.50	-4.34	-6.20	-5.80	-5.40	0.34
90	-0.53	-4.37	-6.32	-5.97	-5.32	0.15
100	-0.56	-4.40	-6.44	-6.14	-5.24	-0.04
110	-0.60	-4.44	-6.55	-6.30	-5.15	-0.24
120	-0.63	-4.47	-6.67	-6.47	-5.07	-0.43
130	-1.02	-4.77	-7.00	-6.67	-5.44	-0.58
140	-1.41	-5.07	-7.34	-6.87	-5.80	-0.73
150	-1.80	-5.37	-7.67	-7.07	-6.17	-0.88
160	-2.19	-5.67	-8.00	-7.27	-6.54	-1.03
170	-2.58	-5.97	-8.34	-7.47	-6.90	-1.18
180	-2.97	-6.27	-8.67	-7.67	-7.27	-1.33





## Lampiran 10. Data ukur kedalaman gerusan abutmen terhadap Model pada jarak 7L<sub>b</sub>

### Data ukur kedalaman gerusan abutmen terhadap MP<sub>1</sub>

		MP1-7Lb																																																		
TMA		9.5																																																		
LEVEL		16.85																																																		
		B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15	B16	B17	B18	B19	B20	B21	B22	B23	B24	B25	B26	B27	B28	B29	B30	B31	B32	B33	B34	B35	B36	B37	B38	B39	B40	B41	B42	B43	B44	B45	B46	B47	B48	B49	B50	B51
A1		0.15	0.25	0.25	0.55	0.85	0.85	0.85	0.45	0	0					1.75	0.85	1.15	1.25	2.05	1.65	0.85	1.15	-0.65	0	0	0	0	0.85	1.65	2.05	2.55	2.15	2.15	2.55	2.15	1.85	1.05	0.85	0.85	0.75	1.55	1.25	0.55	0.55	0.75	0.85	0.85	0.85	1.15	1.15	
A2		0.25	0.15	0.15	0.45	0.65	0.15	-1.15	-1.85	0	0					1.65	2.15	2.35	2.85	3.15	2.85	0.85	-0.05	-3.45	-3.15	-2.35	-1.15	-0.95	-0.15	1.05	1.95	2.35	3.85	2.85	4.05	2.95	2.05	2.45	2.25	1.95	1.65	1.25	0.95	0.75	0.75	0.75	0.85	0.85	1.05	1.05	1.15	
A3		0.45	0.25	0.15	0.15	0.55	0.55	-1.85	-3.05	0	0					-0.75	1.05	1.75	2.85	2.75	3.05	3.15	2.35	1.05	-1.15	-1.55	-1.15	-0.45	-0.15	0.35	2.25	2.45	3.25	3.25	3.35	3.55	2.85	2.55	2.65	2.35	2.15	2.55	3.15	2.75	2.75	1.25	1.15	1.05	1.25	1.25	1.15	
A4		-0.05	0.05	0.65	0.15	0.55	0.65	-1.65	-4.25	-5.75	-5.45	-4.25	-4.95	-5.55	-5.25	-3.25	-2.15	-0.85	-0.45	0.45	1.15	1.35	1.85	1.65	0.55	0.45	0.35	1.55	1.45	1.15	0.95	1.75	1.95	2.15	2.15	2.65	2.35	2.85	2.65	2.15	3.25	4.05	3.25	3.85	3.75	2.65	0.85	0.85	1.15	0.95		
A5		0.05	0.65	0.65	0.15	0.15	0.45	0.55	-1.95	-3.75	-4.55	-4.95	-6.05	-5.75	-5.15	-4.35	-3.65	-3.05	-2.45	-1.75	-1.35	-0.75	-0.35	-0.35	-0.05	0.15	0.45	0.35	0.65	0.65	0.45	0.75	0.85	1.05	0.95	1.15	1.15	1.35	1.85	2.25	2.45	2.95	3.15	3.45	3.55	3.85	3.65	3.25	0.75	0.75	0.65	0.65
A6		0.35	0.25	0.15	0.05	0.05	0.15	0.25	0.15	-1.05	-2.55	-3.45	-3.25	-3.25	-2.85	-2.95	-2.15	-1.85	-1.55	-1.55	-2.05	-1.85	-1.45	-1.35	-1.15	-1.25	-0.85	-0.85	-0.55	-0.55	-0.45	-0.05	0.25	0.25	0.45	0.85	1.15	-0.05	0.75	1.35	2.25	2.35	2.85	3.05	3.25	3.65	3.55	3.15	2.85	1.05	0.95	0.85
A7		0.25	0.15	0.15	0.15	0.05	0.05	-0.05	-0.05	-0.05	-0.55	-0.85	-0.95	-3.15	-1.25	-1.55	-1.85	-2.05	-1.85	-2.55	-2.65	-1.75	-2.45	-2.55	-2.15	-1.85	-1.55	-1.45	-1.55	-1.15	-1.55	-1.25	-0.75	-0.55	0.15	0.95	1.35	1.45	1.15	0.95	1.65	2.35	2.75	3.15	3.15	3.45	2.95	2.75	2.65	1.15	0.85	0.75
TTRK 1		0.95																																																		
TTRK 2		-1.55																																																		
TTRK 3		-3.85																																																		
TTRK 4		-2.85																																																		
TTRK 5		-1.25																																																		
TTRK 6		1.15																																																		

### Data ukur kedalaman gerusan abutmen terhadap MP<sub>2</sub>

		MP2-7Lb																																																			
TMA		9.5																																																			
LEVEL		16.85																																																			
		B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15	B16	B17	B18	B19	B20	B21	B22	B23	B24	B25	B26	B27	B28	B29	B30	B31	B32	B33	B34	B35	B36	B37	B38	B39	B40	B41	B42	B43	B44	B45	B46	B47	B48	B49	B50	B51	
A1		0.45	0.45	0.55	0.35	0.45	0.45	-0.15	-0.05	0	0					0.85	1.35	0.55	1.65	0.65	0.25	0.15	0.15	-0.55	0	0	0	0	-0.35	0.75	2.05	1.65	1.65	0.55	0.65	0.65	0.75	0.75	0.85	0.95	0.95	1.05	0.95	0.95	0.85	1.05	0.85	0.95	0.75	0.55	0.55	0.55	
A2		0.45	0.55	0.55	0.45	0.35	0.45	-0.85	-1.65	0	0					1.05	0.95	1.15	1.25	1.35	1.35	0.35	0.25	-1.05	-3.95	-2.55	-1.95	-1.35	-0.75	-0.35	0.45	1.35	2.15	1.65	1.55	1.65	1.65	0.95	0.75	0.75	0.85	0.85	0.95	0.95	0.75	0.85	0.95	0.95	0.95	0.65	0.65	0.45	0.55
A3		0.35	0.55	0.35	0.45	0.35	0.35	-0.05	-2.45	0	0					0.45	1.55	2.05	2.55	2.95	2.45	1.35	0.55	1.85	-2.55	-2.55	-1.85	-0.65	-0.15	0.45	0.25	0.55	1.75	1.35	1.75	2.45	3.05	2.45	2.15	1.65	1.45	1.25	0.85	0.85	0.85	0.95	0.95	0.95	0.95	0.95	0.65	0.65	0.65
A4		0.45	0.45	0.25	0.25	0.15	0.15	-0.05	-3.25	-4.45	-4.75	-4.85	-5.05	-4.75	-4.55	-3.05	-0.95	-0.35	0.45	1.05	0.95	1.15	1.15	1.15	0.65	-0.05	0.05	-0.15	0.35	0.45	-0.05	0.25	0.85	1.05	1.55	1.75	2.15	2.15	2.55	2.55	2.65	2.65	2.45	2.15	1.95	1.35	0.95	0.65	0.55	0.65	0.55		
A5		0.45	0.35	0.35	0.15	0.25	-0.15	-0.05	-0.95	-3.15	-4.75	-5.25	-5.35	-5.25	-4.85	-4.15	-3.15	-2.15	-1.45	-0.95	-0.65	-0.25	-0.35	0.15	0.25	-0.15	-0.25	-0.55	-0.25	-0.05	-0.25	-0.35	-0.15	-0.85	0.45	0.65	1.05	1.45	1.65	1.85	2.05	2.25	2.35	2.45	2.35	2.55	2.45	2.15	1.55	0.45	0.55	0.55	
A6		0.65	0.55	0.45	0.35	0.25	0.35	0.05	-0.05	-0.35	-1.65	-2.75	-3.75	-3.45	-3.55	-3.05	-1.95	-1.45	-1.05	-0.95	-0.85	-0.75	-0.45	-0.55	-0.45	-0.85	-0.85	-0.75	-0.75	-0.65	-0.45	-0.35	-0.05	0.15	0.45	0.75	1.15	1.35	1.55	1.85	1.95	2.15	2.15	2.15	2.35	2.25	2.15	1.85	0.45	0.45	0.35		
A7		0.85	0.65	0.35	0.25	0.35	0.25	-0.05	-0.25	-0.35	-0.55	-0.65	-1.05	-1.25	-1.35	-1.55	-1.55	-1.35	-1.05	-1.05	-0.95	-0.85	-0.75	-0.85	-0.95	-1.45	-1.35	-1.25	-0.95	-0.75	-0.35	0.15	0.35	0.65	0.75	0.95	1.35	1.35	1.35	1.65	1.55	1.65	1.65	1.65	1.55	1.45	0.85	0.65	0.55	0.45			
TTRK 1		0.25																																																			
TTRK 2		-0.85																																																			
TTRK 3		-3.75																																																			
TTRK 4		-2.55																																																			
TTRK 5		-1.55																																																			
TTRK 6		0.15																																																			

### Data ukur kedalaman gerusan abutmen terhadap MP<sub>3</sub>

		MP3-7Lb																																																				
TMA		9.5																																																				
LEVEL		16.87																																																				
		B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15	B16	B17	B18	B19	B20	B21	B22	B23	B24	B25	B26	B27	B28	B29	B30	B31	B32	B33	B34	B35	B36	B37	B38	B39	B40	B41	B42	B43	B44	B45	B46	B47	B48	B49	B50	B51		
A1		0.03	0.03	-0.57	-0.47	-0.47	-0.17	-0.37	-0.07							1.13	0.63	0.73	0.83	0.53	0.43	0.53	0.43	-1.67						0.13	1.33	2.13	2.03	1.83	2.13	2.23	1.83	1.13	0.63	0.53	0.63	0.63	0.63	0.83	0.73	0.73	0.83	0.93	0.93	0.93	1.03	1.03		
A2		0.03	0.03	0.03	-0.37	-0.57	-0.27	-0.37	-1.67							1.13	0.83	1.13	1.33	1.53	1.23	0.73	0.43	-1.47	-4.47	-5.07	-3.57	-2.77	-1.97	0.13	1.53	2.33	2.63	2.53	2.93	2.73	2.53	2.53	2.23	1.93	1.83	1.13	1.13	1.23	0.93	0.73	0.83	0.83	0.93	0.93	0.83	1.03		
A3		-0.07	-0.07	-0.17	-0.27	-0.27	-0.27	-0.27	-2.27							1.43	1.63	2.23	2.53	2.83	2.03	1.43	0.83	0.33	-2.67	-3.37	-2.87	-1.67	-0.37	1.33	1.43	2.33	1.93	2.73	2.93	2.83	3.03	3.03	3.03	2.63	3.03	2.63	2.63	2.63	2.33	1.93	1.13	1.03	0.93	0.83	0.83	0.93		
A4		0.13	-0.07	-0.27	-0.37	-0.27	-0.27	-0.27	-2.37	-3.67	-3.47	-3.17	-3.17	-3.07	-3.17	-2.27	-0.97	0.53	0.53	0.53	1.13	0.93	0.53	0.33	0.13	0.03	-0.47	-0.77	-0.37	-0.47	0.43	0.73	1.03	1.53	1.63	1.93	2.03	2.83	2.63	2.83	2.83	2.83	3.03	3.13	3.03	3.03	2.83	2.63	2.23	0.83	0.83			
A5		0.03	-0.17	0.03	-0.27	-0.17	-0.37	-0.37	-0.77	-1.77	-2.57	-3.07	-3.37	-3.67	-3.77	-3.37	-3.17	-2.47	-1.87	-1.27	-0.77	-0.57	-0.57	-0.57	-0.57	-0.47	-0.37	-0.37	-0.37	-0.27	-0.17	0.13	0.33	0.73	0.93	1.23	1.43	1.63	2.03	2.23	2.33	2.63	2.73	2.73	3.03	3.03	2.93	2.83	2.53	0.63	0.63			
A6		0.13	0.03	-0.07	-0.17	-0.07	-0.27	-0.27	-0.47	-0.67	-0.57	-1.67	-2.27	-2.87	-3.47	-3.47	-3.37	-3.17	-3.17	-2.87	-2.27	0.03	-1.77	-1.57	-1.17	-0.97	-0.87	-0.87	-0.67	-0.37	-0.07	0.13	0.33	0.53	0.73	0.93	1.13	1.33	1.63	1.83	2.13	2.33	2.53	2.63	2.73	2.93	2.83	2.63	2.53	0.63	0.63			
A7		0.13	0.13	0.03	-0.07	-0.17	-0.17	-0.27	-0.37	-0.37	-0.57	-0.57	-0.97	-1.57	-1.97	-3.07	-3.47	-3.37	-3.17	-3.17	-3.17	-3.17	-3.17	-3.17	-3.17	-2.27	-2.27	-2.47	-2.47	1.83	-1.37	-0.57	-0.27	0.13	0.23	0.43	0.63	0.83	1.13	1.33	1.63	1.73	1.83	2.03	2.13	2.23	2.23	2.13	2.23	2.13	1.83	1.93	1.83	0.73
TTRK 1		0.63																																																				
TTRK 2		-2.37																																																				
TTRK 3		-4.97																																																				
TTRK 4		-4.57																																																				
TTRK 5		-3.17																																																				
TTRK 6		3.23																																																				

## Lampiran 11. Data ukur kedalaman gerusan abutmen terhadap Model pada jarak 9L<sub>b</sub>

### Data ukur kedalaman gerusan abutmen terhadap MP<sub>1</sub>

MP1-9L<sub>b</sub>

TMA	9.5																																																			
LEVEL	16.87																																																			
	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15	B16	B17	B18	B19	B20	B21	B22	B23	B24	B25	B26	B27	B28	B29	B30	B31	B32	B33	B34	B35	B36	B37	B38	B39	B40	B41	B42	B43	B44	B45	B46	B47	B48	B49	B50	B51	
A1	0.43	0.03	0.33	0.33							1.03	1.03	1.73	2.43	2.83	2.13	1.13	0.33	0.73	0.53	0.83	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07	0.53	1.13	2.13	2.43	1.93	2.13	1.83	0.73	0.53	0.53	0.63	0.73	0.73	0.63	0.73	0.63	0.73	0.63	0.73	0.63	0.53	0.53	0.53	0.63	
A2	0.53	-1.97	-2.57	-2.47							0.83	1.33	1.83	2.73	3.13	3.13	2.83	2.73	1.73	1.33	0.13	0.13	-1.07	-4.17	-4.27	-2.87	-1.47	-1.07	-0.07	1.83	1.63	2.43	2.53	2.63	2.13	2.13	0.83	0.83	0.83	0.73	0.73	0.73	0.63	0.73	0.63	0.73	1.53	0.53	0.53	0.53		
A3	0.13	-0.37	-2.17	-3.97							0.13	1.83	2.33	2.73	2.83	3.43	3.53	3.53	3.63	3.63	2.83	1.23	-0.57	-2.07	-3.07	-2.07	-1.57	-0.87	-0.27	0.33	0.83	1.33	2.43	2.83	3.23	1.73	1.83	2.23	2.33	1.43	1.53	0.83	0.83	0.83	0.83	0.83	0.83	0.73	0.43	0.53	0.63	
A4	0.23	0.23	-1.27	-4.37	-5.47	-5.47	-4.87	-4.37	-3.27	-3.27	-1.57	-0.37	0.03	0.33	0.83	1.23	1.83	2.33	2.13	2.13	2.03	2.43	1.53	0.33	-0.07	-0.27	-1.87	1.23	1.43	1.83	1.43	1.23	1.63	2.13	2.33	2.43	2.43	2.53	2.13	2.43	2.13	2.13	0.83	1.13	0.83	0.83	1.13	0.53	0.43	0.53	0.63	
A5	0.53	0.23	0.23	-1.87	-3.17	-3.57	-4.47	-4.47	-3.97	-4.27	-3.27	-2.87	-2.17	-1.07	-0.27	0.33	0.13	0.73	1.33	1.43	0.93	0.83	1.13	0.53	1.13	1.23	-0.27	-0.27	0.63	1.33	0.73	0.43	0.43	0.93	1.63	1.93	2.33	2.43	2.73	2.73	2.03	2.03	2.03	0.93	1.93	0.83	0.93	0.63	0.73	0.63	0.43	
A6	0.73	0.63	0.33	0.13	0.03	-1.57	-1.87	-2.77	-3.07	-2.87	-2.17	-2.47	-2.07	-1.77	-0.57	0.63	-0.67	-0.17	0.33	0.23	0.53	1.03	-0.07	1.13	1.03	1.13	1.23	1.13	1.13	0.53	0.43	0.13	0.83	1.43	1.63	1.93	2.13	2.13	1.93	1.63	1.83	2.13	1.83	1.63	1.73	0.83	0.73	0.93	0.43	0.53		
A7	0.73	0.63	0.43	0.23	0.23	0.03	-0.17	-0.57	-0.97	-2.37	-3.27	-2.57	-1.57	-1.37	-1.07	-1.07	-1.07	-2.07	-1.27	-0.57	0.43	0.53	0.43	0.43	1.43	1.73	1.13	1.43	1.33	1.13	1.53	0.43	1.33	1.43	1.83	1.93	1.13	0.83	1.13	0.33	1.43	1.63	1.63	2.03	1.93	1.83	1.83	0.93	0.73	1.63	0.93	0.83
TITIK 1	0.13																																																			
TITIK 2	-1.27																																																			
TITIK 3	-4.37																																																			
TITIK 4	-3.77																																																			
TITIK 5	-2.77																																																			
TITIK 6	0.63																																																			

### Data ukur kedalaman gerusan abutmen terhadap MP<sub>2</sub>

MP2-9L<sub>b</sub>

TMA	9.5																																																			
LEVEL	16.87																																																			
	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15	B16	B17	B18	B19	B20	B21	B22	B23	B24	B25	B26	B27	B28	B29	B30	B31	B32	B33	B34	B35	B36	B37	B38	B39	B40	B41	B42	B43	B44	B45	B46	B47	B48	B49	B50	B51	
A1	-0.07	-0.17	-0.17	0.03							1.53	1.63	1.23	1.33	1.83	0.93	0.73	0.73	0.63	0.63	-4.37	0.63	-1.07	0	0	0	0	0	0.53	0.93	1.43	1.93	1.93	1.23	1.43	0.93	0.73	0.73	0.73	0.63	0.73	0.63	0.83	0.83	0.93	0.83	0.83	0.83	0.73	0.93	0.83	0.73
A2	0.13	-1.67	-1.27	-1.27							1.23	1.63	1.73	2.23	2.23	1.83	2.23	1.83	1.13	0.53	0.53	0.43	-1.27	-3.27	-2.97	-2.17	-1.67	-0.67	0.03	0.93	0.53	1.23	2.13	2.23	1.23	2.03	2.33	1.23	1.23	0.83	0.83	0.73	0.63	0.83	0.73	0.83	0.93	0.73	1.23	0.73	0.73	
A3	0.33	-0.97	-3.47	-4.37							-1.17	1.23	2.43	2.63	3.03	2.93	2.63	3.53	3.43	3.23	2.03	1.13	-0.17	-1.87	-2.47	-2.07	-1.37	-0.97	0.23	1.33	0.73	0.83	2.23	2.83	2.33	2.43	2.43	2.63	2.63	2.03	1.03	1.23	1.33	0.93	1.23	1.03	1.23	0.73	1.83	0.83	0.83	
A4	0.23	0.23	-2.57	-4.87	-6.27	-6.17	-5.97	-4.97	-4.97	-4.27	-2.77	-0.97	-0.67	0.03	0.23	1.83	2.03	1.73	2.13	2.63	2.43	2.53	1.83	0.23	0.03	0.13	0.03	0.43	1.33	0.33	1.13	1.53	2.13	2.73	2.63	2.83	3.03	2.93	3.03	2.63	2.23	2.23	2.03	1.83	1.53	1.23	1.33	0.63	1.23	0.93	0.83	
A5	0.43	0.23	0.03	-2.57	-4.47	-5.17	-5.17	-4.97	-4.97	-4.07	-3.57	-2.87	-2.27	-1.67	-0.87	-0.37	0.63	0.93	1.13	1.13	1.33	1.13	1.23	1.03	1.13	0.73	0.03	0.23	0.43	-0.47	0.23	0.93	1.13	1.23	1.73	2.23	2.73	2.93	3.03	3.03	2.63	2.33	2.13	2.03	2.13	1.93	1.73	1.43	1.13	0.93	1.03	
A6	0.53	0.33	0.23	0.13	-0.67	-1.37	-1.67	-1.77	-2.37	-2.27	-2.27	-2.07	-1.77	-1.07	-0.57	-0.17	0.03	0.23	0.23	0.33	0.23	0.33	0.23	0.43	0.23	0.63	0.83	0.43	0.23	0.53	0.83	1.23	1.13	1.13	1.23	1.93	2.33	2.23	2.43	2.63	2.03	1.93	2.03	2.03	1.93	1.63	2.03	2.13	1.53	1.13	0.93	
A7	0.63	0.53	0.33	0.23	0.13	-0.27	-0.37	-0.87	-1.17	-1.17	-0.97	-0.77	-0.87	-1.17	-0.97	-1.37	-1.07	-1.47	-0.87	-0.97	-0.17	-0.37	0.13	0.63	-0.77	0.03	0.73	0.93	0.83	1.23	1.73	1.73	1.53	1.53	1.43	1.73	1.53	2.23	1.73	1.93	1.83	2.13	2.13	2.23	2.23	1.83	2.13	1.83	1.03	1.23	1.13	
TITIK 1	0.13																																																			
TITIK 2	-1.47																																																			
TITIK 3	-3.37																																																			
TITIK 4	-2.27																																																			
TITIK 5	-1.87																																																			
TITIK 6	0.03																																																			

### Data ukur kedalaman gerusan abutmen terhadap MP<sub>3</sub>

MP3-9L<sub>b</sub>

TMA	9.5																																																		
LEVEL	16.87																																																		
	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15	B16	B17	B18	B19	B20	B21	B22	B23	B24	B25	B26	B27	B28	B29	B30	B31	B32	B33	B34	B35	B36	B37	B38	B39	B40	B41	B42	B43	B44	B45	B46	B47	B48	B49	B50	B51
A1	0.43	0.13	0.23	0.13							1.33	1.23	1.23	1.33	1.33	2.33	0.93	0.63	0.33	0.43	0.53	0.43	-2.37	0	0	0	0	0.53	0.83	1.73	2.63	4.33	2.83	2.73	2.33	3.33	2.63	1.13	1.93	1.93	0.93	1.03	1.23	1.13	1.23	1.53	-0.47	0.93	0.93	0.63	1.53
A2	0.33	0.13	-0.37	-1.57							1.23	1.13	1.43	2.13	2.53	1.83	1.63	1.33	1.13	0.53	0.63	0.43	-1.77	-4.07	-4.37	-3.17	-2.67	-2.07	-0.57	0.23	1.33	2.83	2.43	2.03	2.53	3.53	2.63	2.13	2.23	2.63	1.53	1.33	0.63	1.33	1.93	1.03	1.43	1.43	0.63	1.33	
A3	0.33	0.23	-0.17	-2.87							0.83	1.23	2.03	2.33	2.53	3.13	2.43	2.33	2.03	1.73	1.13	0.63	-0.67	-3.27	-3.97	-2.97	-2.17	-1.37	0.23	1.43	2.13	2.73	1.23	2.03	1.43	2.23	2.83	2.53	2.13	1.83	2.93	2.13	2.33	1.23	0.83	1.83	1.83	1.53	1.93	1.83	1.73
A4	0.33	0.23	-0.07	-2.57	-4.27	-4.07	-3.57	-4.17	-3.67	-3.37	-15.01	1.83	1.53	2.83	-0.27	0.23	0.53	0.63	0.73	0.43	0.63	0.43	0.23	0.13	-0.17	-0.47	-0.57	-0.47	0.63	1.13	0.53	1.43	1.33	1.73	2.03	2.13	2.23	2.33	2.33	2.43	2.63	3.03	3.43	3.03	2.83	2.73	2.13	2.53	2.23	2.13	
A5	0.53	0.13	0.03	-0.77	-2.77	-3.87	-4.77	-4.67	-4.77	-4.47	-2.07	3.37	2.67	2.07	-1.77	-1.47	-1.07	-0.77	-0.57	-0.57	-0.47	-0.37	-0.27	-0.47	-0.37	-0.27	-0.17	-0.07	0.13	0.43	0.83	1.03	1.13	1.43	1.63	1.73	1.83	2.03	2.13	2.33	2.33	2.53	2.73	2.83	2.93	2.63	2.53	2.13	1.83		
A6	0.53	0.43	0.33	0.33	-0.27	-0.77	-2.27	-2.47	-2.47	-2.67	-2.37	-2.67	-2.27	-2.17	-2.27	-1.57	-1.17	-1.17	-1.77	-1.07	-0.67	-0.77	-0.87	-1.17	-0.87	-0.87	-0.57	-0.77	-0.47	-0.57	-0.27	0.03	0.43	0.33	0.43	1.73	0.83	1.13	1.33	1.53	1.53	1.83	2.03	2.33	2.33	2.63	2.53	2.43	2.53	2.63	2.33
A7	0.73	0.43	0.53	0.33	0.13	0.23	-0.07	-0.57	-1.07	-2.37	-2.77	-3.67	-3.97	-2.57	-2.17	-2.67	-2.37	-2.27	-2.57	-1.27	-0.77	-0.87	-0.87	-1.07	-1.07	-0.97	-0.87	-1.17	-0.97	-0.77	-0.57	-0.17	-0.47	-0.37	0.03	0.43	0.23	0.53	1.33	1.33	0.63	1.53	1.93	2.03	1.93	2.33	2.33	2.43	2.73	3.33	2.63
TITIK 1	0.63																																																		
TITIK 2	-2.47																																																		
TITIK 3	-4.47																																																		
TITIK 4	-4.17																																																		
TITIK 5	-2.67																																																		
TITIK 6	3.03																																																		

Lampiran 12. Perhitungan non-linear berganda untuk kedalaman gerusan

Model	Titik	$\frac{UL_b}{\vartheta}$	$\frac{U^2}{g L_b}$	ds	$(x_{1i} - \bar{x}_1)^2$	$(x_{2i} - \bar{x}_2)^2$	$(y_i - \bar{y})^2$	$\frac{(x_{1i} - \bar{x}_1)}{x(x_{2i} - \bar{x}_2)}$	$\frac{(x_{1i} - \bar{x}_1)}{x(y_i - \bar{y})}$	$\frac{(x_{2i} - \bar{x}_2)}{x(y_i - \bar{y})}$	$y_i' = \beta_0 + \beta_1 x_1 + \beta_2 x_2$	$(y_i - y_i')^2$
		$X_1$	$X_2$	y								
MP1	1	54090.200	0.204	7.170	482801962.658	0.01481	3.26003	2674.332	-39673.030	-0.2197564	9.721	6.506
	2	34583.882	0.084	8.570	6083314.821	0.00000	0.16448	2.044	-1000.278	-0.0003361	9.902	1.775
	3	36061.816	0.091	11.670	15558061.213	0.00007	7.26003	32.050	10627.888	0.0218937	10.011	2.753
	4	57046.066	0.227	11.070	621436160.097	0.02093	4.38670	3606.403	52211.612	0.3030015	9.388	2.828
	5	40798.951	0.116	10.070	75368555.426	0.00113	1.19781	291.447	9501.427	0.0367417	10.224	0.024
	6	24551.837	0.042	6.670	57238428.452	0.00165	5.31559	307.402	17442.930	0.0936781	8.635	3.862
MP2	7	17353.433	0.021	7.170	217976049.200	0.00381	3.26003	911.128	26657.244	0.1114258	7.157	0.000
	8	22316.931	0.035	8.770	96050070.691	0.00230	0.04225	469.953	2014.550	0.0098568	8.227	0.295
	9	28891.055	0.058	10.670	10409593.017	0.00060	2.87114	78.804	-5466.939	-0.0413865	9.297	1.886
	10	27280.429	0.052	9.570	23396720.235	0.00095	0.35336	148.726	-2875.337	-0.0182777	9.071	0.249
	11	24759.044	0.043	8.970	54146064.463	0.00159	0.00003	293.728	40.880	0.0002218	8.671	0.090
	12	19016.407	0.025	7.270	171637179.414	0.00330	2.90892	753.124	22344.547	0.0980453	7.540	0.073
MP3	13	35602.248	0.089	6.670	12143853.715	0.00003	5.31559	20.295	-8034.408	-0.0134271	9.979	10.951
	14	38085.557	0.101	9.770	35618361.838	0.00035	0.63114	111.080	4741.333	0.0147864	10.127	0.127
	15	41825.643	0.122	11.770	94249119.690	0.00156	7.80892	383.469	27129.022	0.1103792	10.243	2.333
	16	43082.421	0.130	11.470	120230704.143	0.00220	6.22225	514.884	27351.524	0.1171319	10.253	1.482
	17	25283.502	0.045	9.970	46702768.802	0.00145	0.98892	260.259	-6795.976	-0.0378717	8.759	1.467
	18	7484.584	0.004	4.270	606777844.007	0.00622	22.14225	1942.139	115911.296	0.3710021	4.356	0.007
$\Sigma$		578114.006	1.490	161.560	2747824811.881	0.06295	74.129	12801.266	252128.287	0.957		36.70730964

$$\begin{aligned} \bar{x}_1 &= 32117.445 \\ \bar{x}_2 &= 0.083 \\ \bar{y} &= 8.976 \\ S_y^2 &= 4.36056 \end{aligned}$$

$$\begin{aligned} \text{Pers. } 2747824811.881 \beta_1 + 12801.266 \beta_2 &= 252128.2867 & S_y^2 &= 2.44715 \\ 12801.266 \beta_1 + 0.062947 \beta_2 &= 0.9571087 & S_y &= 1.56434 \end{aligned}$$

$$\beta_1 = \text{Det} \frac{\begin{vmatrix} 252128.287 & 12801.266 \\ 0.957109 & 0.063 \end{vmatrix}}{\begin{vmatrix} 2747824811.881 & 12801.266 \\ 12801.266 & 0.063 \end{vmatrix}} = \frac{3618.62160}{9096066.55109} = 0.000398 \quad r^2 = 0.439$$

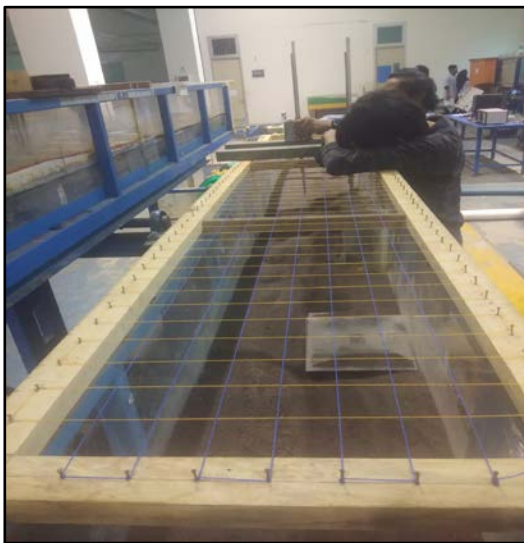
$$\beta_2 = \text{Det} \frac{\begin{vmatrix} 2747824811.881 & 252128.287 \\ 12801.2663759 & 0.9571087 \end{vmatrix}}{\begin{vmatrix} 2747824811.881 & 12801.266 \\ 12801.26638 & 0.06295 \end{vmatrix}} = \frac{-597594199.7}{9096066.551} = -65.698$$

$$\begin{aligned} \beta_0 &= 8.976 - 0.0003978 \times 32117.445 - (-65.698) \times 0.083 \\ &= 1.636 \end{aligned}$$

## Lampiran 13. Perhitungan lebar dan panjang kedalaman gerusan di abutmen

Model	Titik Pengamatan	Kedalaman Gerusan			$U$	$L_b$	$\theta$	$\frac{d_s}{L_b}$	$\frac{UL_b}{\theta}$	$\frac{U^2}{g L_b}$	L	P	L/ds	P/ds	U/u*
		ds rerata	Gerusan Relatif (ds)	cm											
		cm	cm	cm/dtk	cm	cm <sup>2</sup> /dtk					cm	cm			
MP <sub>1</sub>	1	0.130	7.170	44.787			0.717	54090.200	0.204				2.789	3.487	18.583
	2	-1.270	8.570	28.635			0.857	34583.882	0.084				2.334	2.917	11.881
	3	-4.370	11.670	29.859			1.167	36061.816	0.091				1.714	2.142	12.389
	4	-3.770	11.070	47.234	10	0.0083	1.107	57046.066	0.227	20.000	25.000		1.807	2.258	19.598
	5	-2.770	10.070	33.782			1.007	40798.951	0.116				1.986	2.483	14.017
	6	0.630	6.670	20.329			0.667	24551.837	0.042				2.999	3.748	8.435
MP <sub>2</sub>	7	0.130	7.170	14.369			0.717	17353.433	0.021				3.487	4.184	5.962
	8	-1.470	8.770	18.478			0.877	22316.931	0.035				2.851	3.421	7.667
	9	-3.370	10.670	23.922			1.067	28891.055	0.058				2.343	2.812	9.926
	10	-2.270	9.570	22.588	10	0.0083	0.957	27280.429	0.052	25.000	30.000		2.612	3.135	9.372
	11	-1.670	8.970	20.500			0.897	24759.044	0.043				2.787	3.344	8.506
	12	0.030	7.270	15.746			0.727	19016.407	0.025				3.439	4.127	6.533
MP <sub>3</sub>	13	0.630	6.670	29.479			0.667	35602.248	0.089				4.498	4.498	12.231
	14	-2.470	9.770	31.535			0.977	38085.557	0.101				3.071	3.071	13.084
	15	-4.470	11.770	34.632			1.177	41825.643	0.122				2.549	2.549	14.369
	16	-4.170	11.470	35.672	10	0.0083	1.147	43082.421	0.130	30.000	30.000		2.616	2.616	14.801
	17	-2.670	9.970	20.935			0.997	25283.502	0.045				3.009	3.009	8.686
	18	3.030	4.270	6.197			0.427	7484.584	0.004				7.026	7.026	2.571

## Lampiran 14. Dokumentasi penelitian



Pengukuran kontur gerusan

Pengukuran Kecepatan aliran MP<sub>2</sub>



Pengukuran kecepatan aliran MP<sub>3</sub>



Skema kedalaman gerusan tanpa SPE



Pengukuran gerusan MP<sub>1</sub> – 3L<sub>b</sub>



Pengukuran gerusan MP<sub>1</sub> – 5L<sub>b</sub>



Pengukuran gerusan MP<sub>2</sub> – 3L<sub>b</sub>Pengukuran gerusan MP<sub>2</sub> – 5L<sub>b</sub>Pengukuran gerusan MP<sub>3</sub> – 5L<sub>b</sub>Pengukuran gerusan MP<sub>3</sub> – 7L<sub>b</sub>Pengukuran gerusan MP<sub>3</sub> – 7L<sub>b</sub>Pengukuran gerusan MP<sub>2</sub> – 7L<sub>b</sub>