BAB V

PENUTUP

V.1 Kesimpulan

Berdasarkan hasil yang diperoleh dari penelitian ini, maka dapat disimpulkan sebagai berikut :

1. Berdasarkan kecepatan gelombang geser hingga kedalaman 30 meter yang diperoleh, struktur perlapisan sub-permukaan tanah terdiri atas lima lapisan. Lapisan tersebut terdiri dari *soft clay, clay and silt, sandy clays, medium to dense sand* dan *medium to dense gravel* dengan nilai Vs_{30} yaitu 225.3 m/s yang diklasifikasikan sebagai situs kelas D atau tanah sedang (*stiff soil*).
2. Kecepatan gelombang geser (Vs) meningkat berdasarkan bertambahnya jumlah kompaksi yang dilakukan, dimana kompaksi 30 *passes* memiliki nilai Vs rata-rata dan daya dukung ijin terbesar yaitu 156.2 m/s dan 190.3 kPa. Perubahan Vs rata-rata pada kompaksi 0 - 5, 5 - 10 serta 10 - 30 *passes* secara berurutan adalah 9.2 m/s, 6.6 m/s dan 5.6 m/s dengan perubahan Vs rata-rata dari 0 – 30 *passes* yaitu 21.4 m/s.

V.2 Saran

Adapun saran untuk penelitian selanjutnya yaitu :

1. Sebaiknya dilakukan interval pelewatan kompaksi yang konstan untuk mengetahui lebih jelas efek kompaksi pada setiap lintasan.
2. Sebaiknya dilakukan pengambilan data pendukung seperti data bor atau NSPT tanah sebagai korelasi dalam melakukan interpretasi sub-permukaan tanah.

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L A M P I R A N

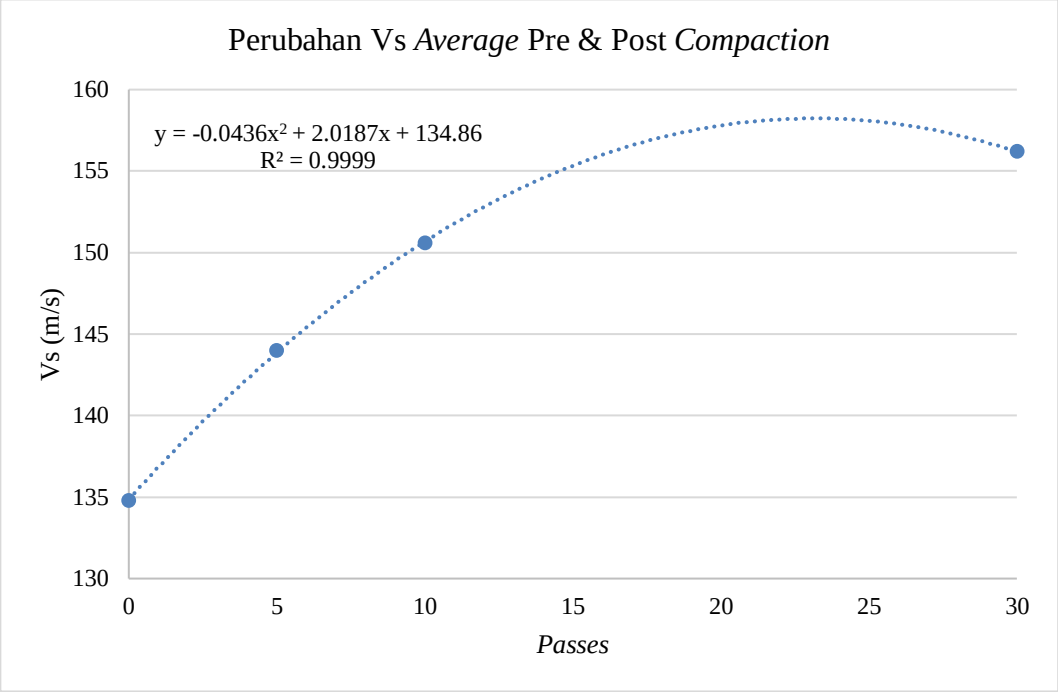
LAMPIRAN 1 Tabel Hasil Pengolahan Data

Tabel hasil pengolahan data untuk 0, 5, 10 dan 30 passes

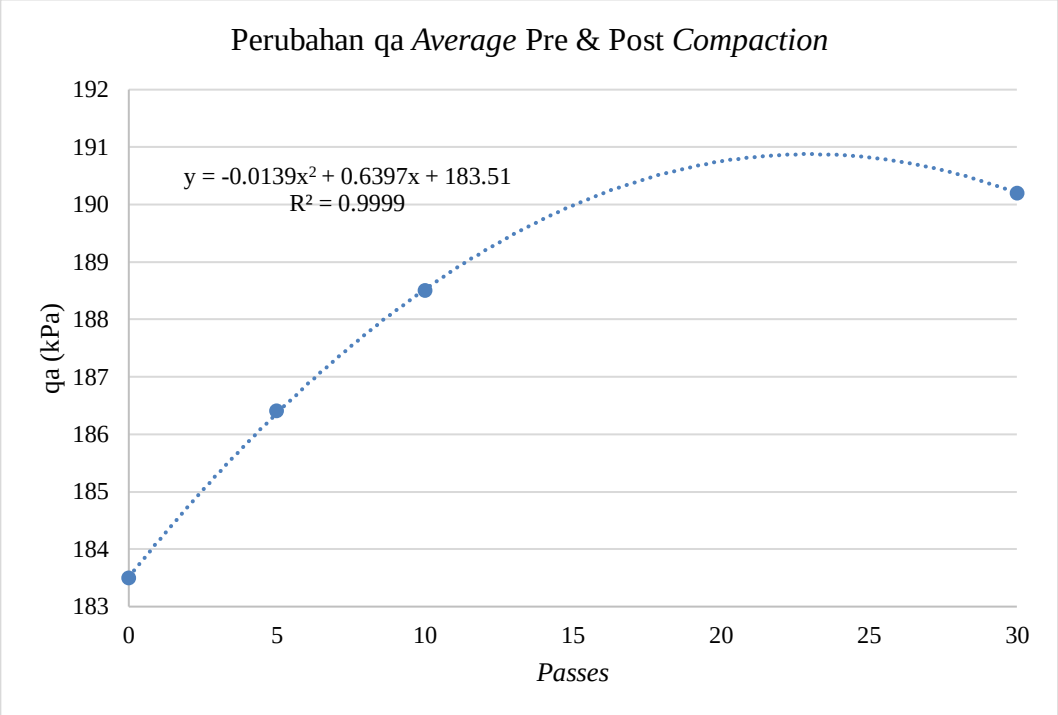
No	Lane	0 Passes					5 Passes					10 Passes					30 Passes				
		Thickness	h (m)	Vs (m/s)	qa (kN/m^2)	Vs30	Thickness	h (m)	Vs (m/s)	qa (kN/m^2)	Vs30	Thickness	h (m)	Vs (m/s)	qa (kN/m^2)	Vs30	Thickness	h (m)	Vs (m/s)	qa (kN/m^2)	Vs30
1	A	0.5	0.5	107.1	172.91228	136.1	0.5	0.5	119.7	177.7878206	144										
2		0.5	1	117.4	176.927562		0.5	1	125	179.723957											
3		0.5	1.5	124.7	179.616025		0.5	1.5	131.1	181.8775693											
4		0.5	2	129.7	181.390051		0.5	2	138.1	184.2582271											
5		0.5	2.5	136	183.553722		0.5	2.5	145.7	186.7425808											
6		0.4	2.9	142	148.436444		0.5	3	149	187.7911129											
7		0.5	3.4	144.7	186.42133		0.5	3.5	154	189.347096											
8		0.6	4	154.9	227.547762		0.5	4	157.9	190.5346652											
9		0.5	4.5	161.8	191.700435		0.5	4.5	163.8	192.2901078											
10		0.5	5	165.4	192.75797		0.5	5	175.2	195.5518793											
11	B	0.5	0.5	101.4	170.56423	133.4						0.5	0.5	124.2	179.435706	150.6					
12		0.5	1	108.9	173.634267							0.5	1	132.3	182.292344						
13		0.5	1.5	120.7	178.157983							0.5	1.5	138.5	184.391506						
14		0.5	2	128.3	180.89857							0.5	2	146.9	187.125907						
15		0.5	2.5	138.6	184.424781							0.5	2.5	150.3	188.199391						
16		0.5	3	140.4	185.020668							0.5	3	155.1	189.684314						
17		0.5	3.5	149.5	187.948458							0.5	3.5	159	190.865639						
18		0.5	4	153.2	189.10071							0.5	4	168.2	193.568626						
19		0.5	4.5	158.8	190.80559							0.5	4.5	172.6	194.8223						
20		0.5	5	166.5	193.077661							0.5	5	177.8	196.273383						
21	C	0.5	0.5	103	171.233122	134.9											0.5	0.5	130.8	181.773431	156.2
22		0.5	1	114.4	175.78628												0.5	1	139.7	184.789619	
23		0.5	1.5	116.4	176.54959												0.5	1.5	143.1	185.903847	
24		0.5	2	128.9	181.109694												0.5	2	151.4	188.542793	
25		0.5	2.5	134.7	183.113502												0.5	2.5	156.8	190.201958	
26		0.5	3	138.6	184.424781												0.5	3	162.8	191.99595	
27		0.5	3.5	155.9	189.928438												0.5	3.5	167.4	193.338049	
28		0.5	4	162.6	191.936956												0.5	4	171.3	194.454416	
29		0.5	4.5	163.8	192.290108												0.5	4.5	174.5	195.356257	
30		0.5	5	165.7	192.845316												0.5	5	179.9	196.850381	
Average						134.8															

LAMPIRAN 2 Grafik Perubahan Vs dan q_a

Gambar Grafik perubahan Vs terhadap pelewatan kompaksi

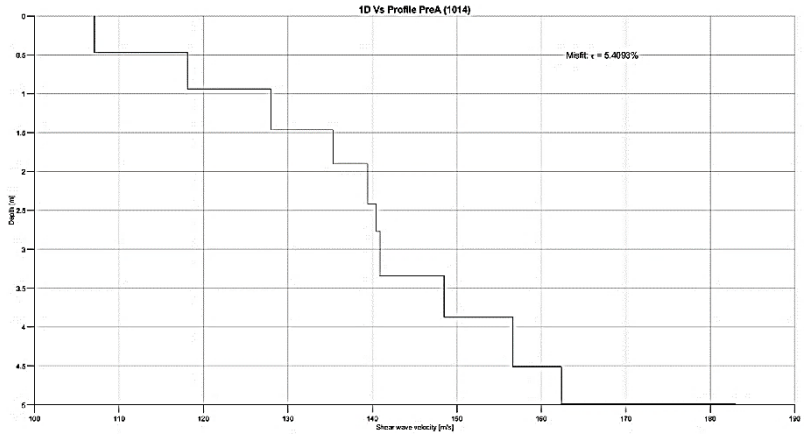


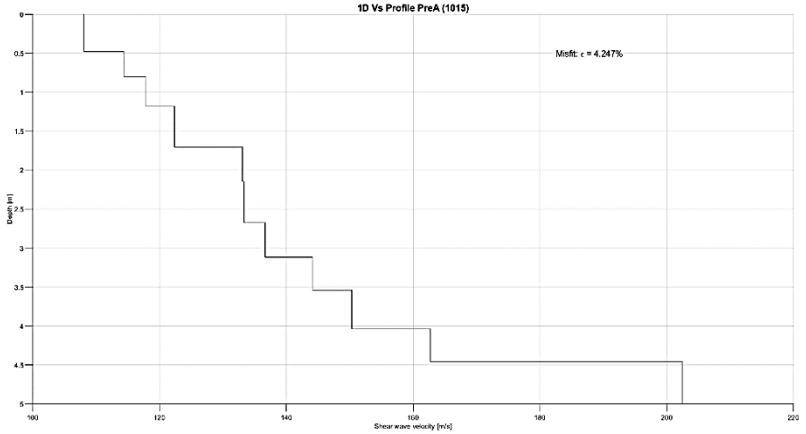
Gambar Grafik perubahan daya dukung izin (q_a) terhadap pelewatan kompaksi

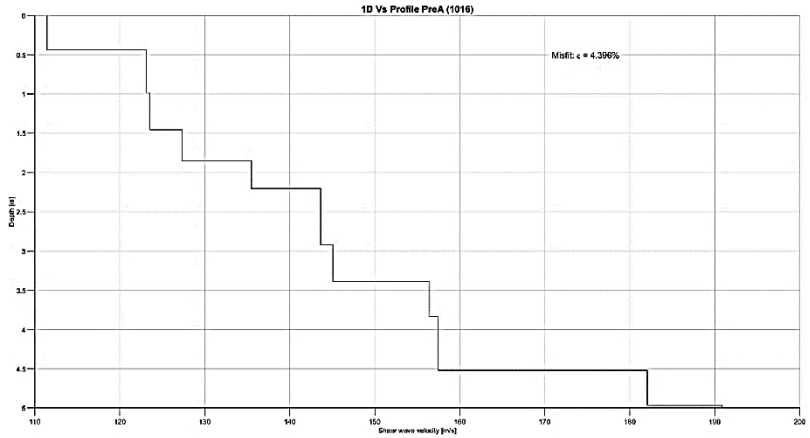


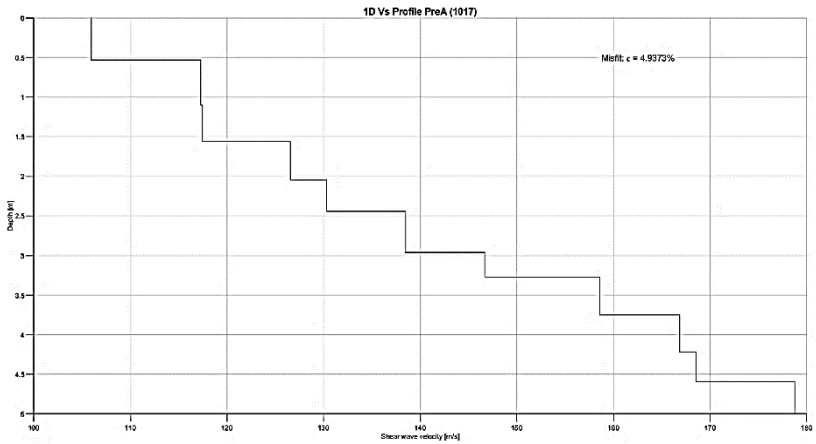
LAMPIRAN 3 Profil Vs 1D

PreA 0 *passes*

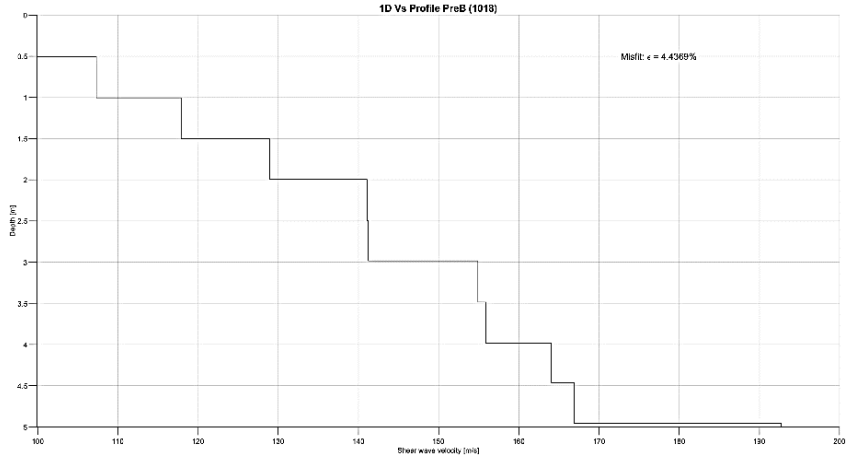


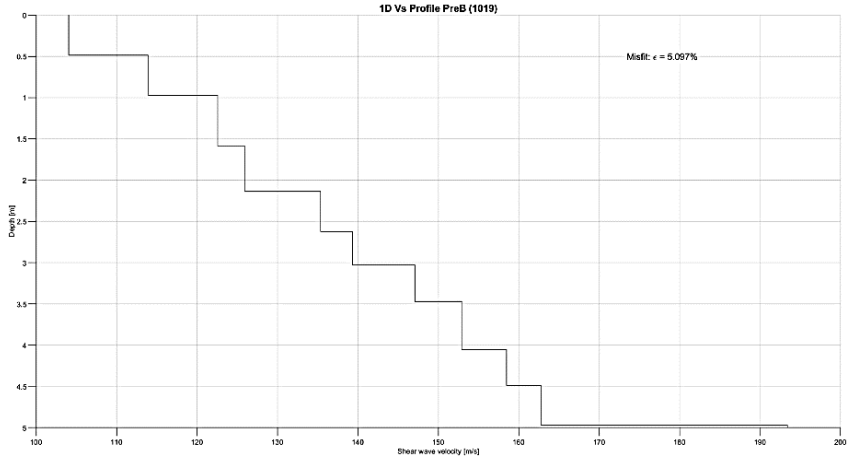


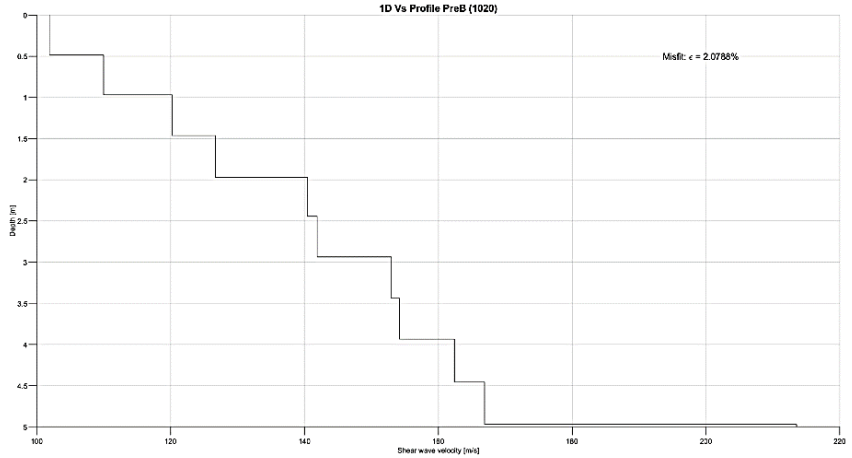


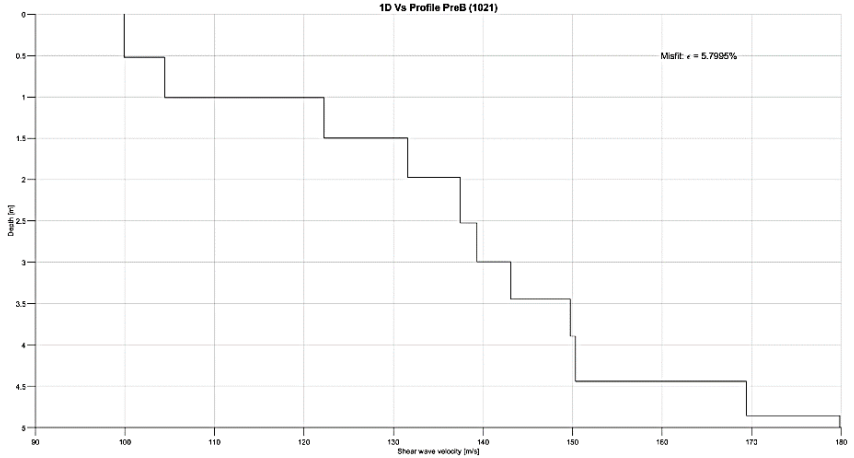


PreB 0 *passes*

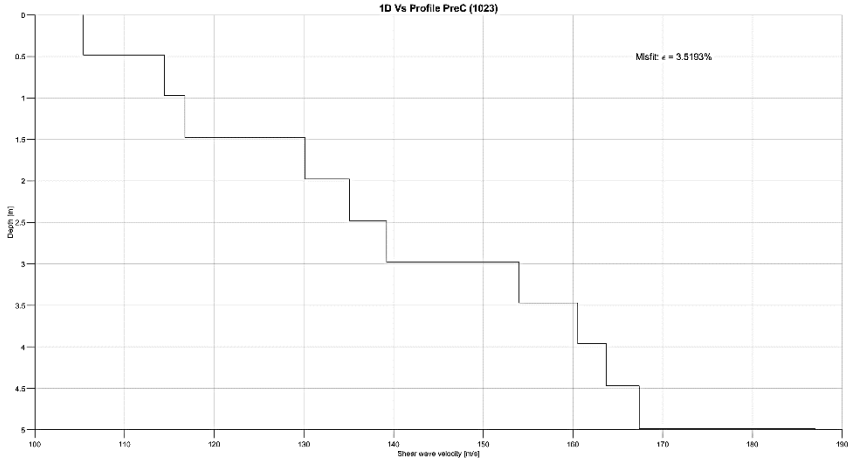


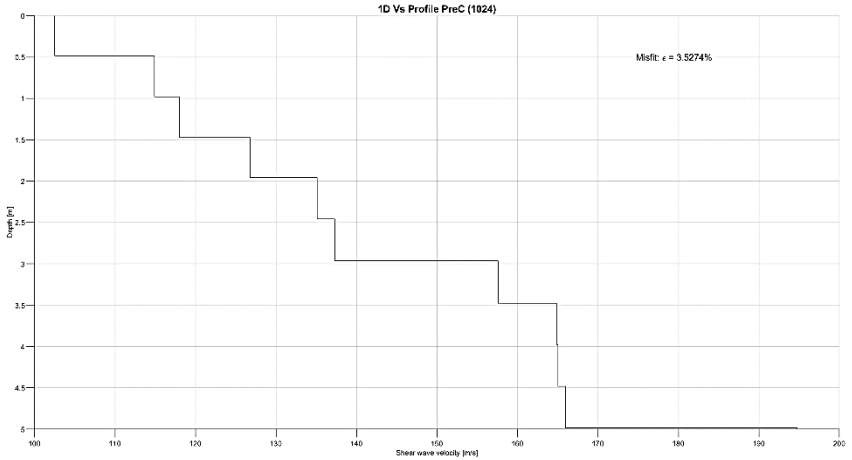


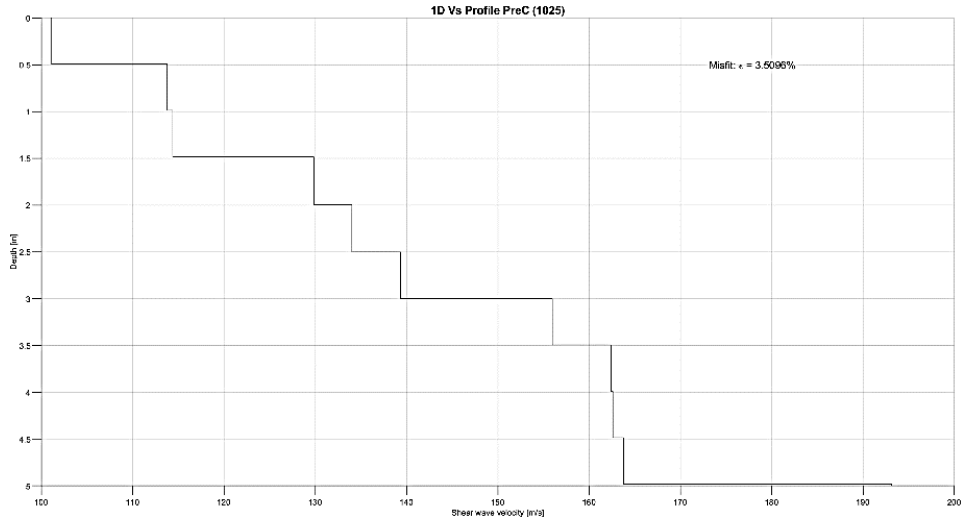




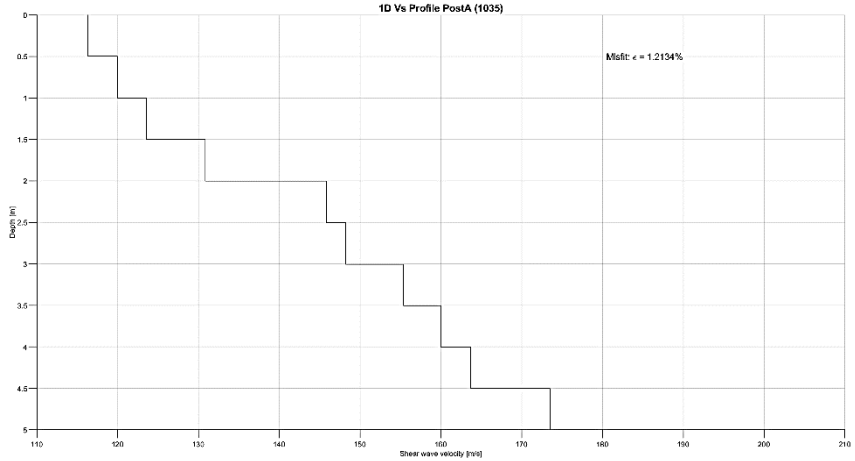
PreC 0 *passes*

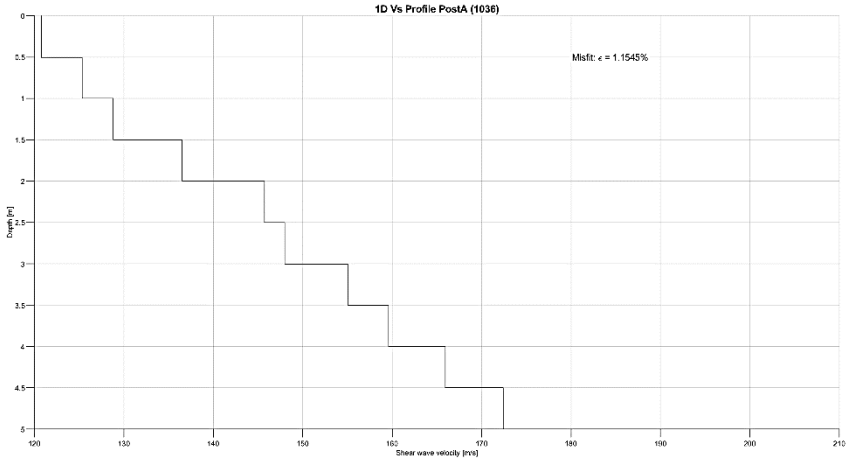


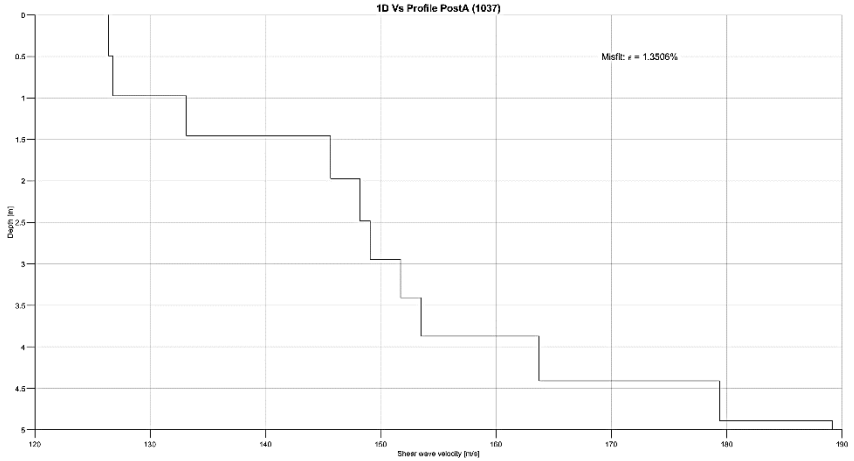


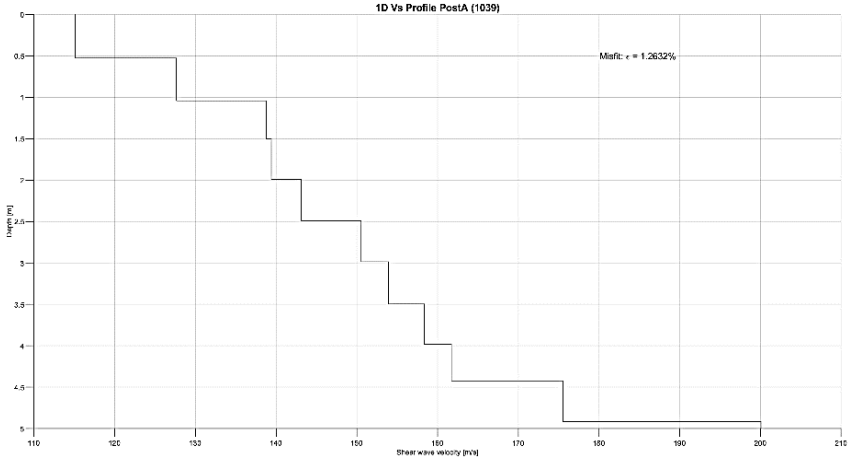


PostA 5 *passes*

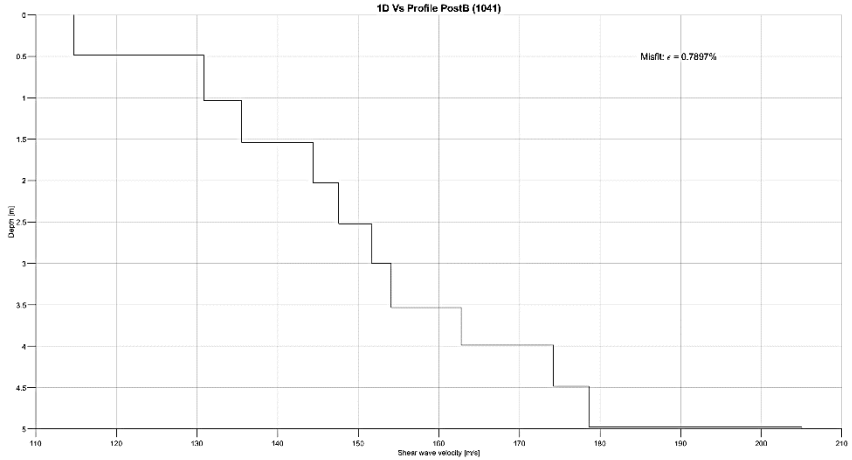


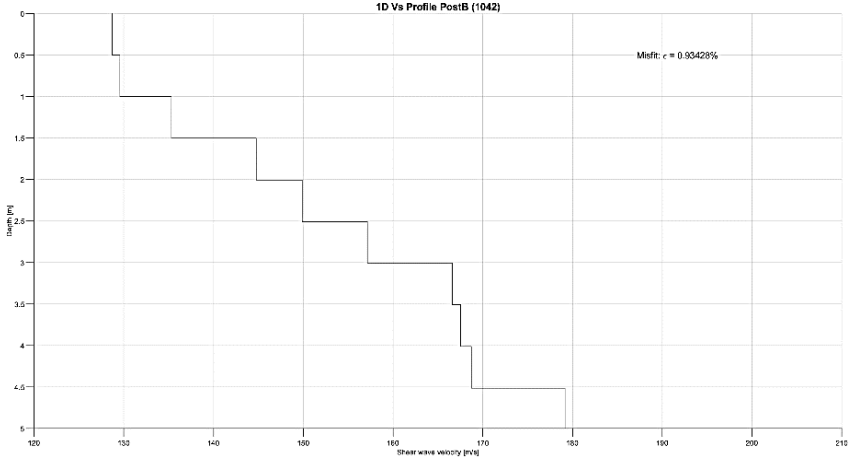


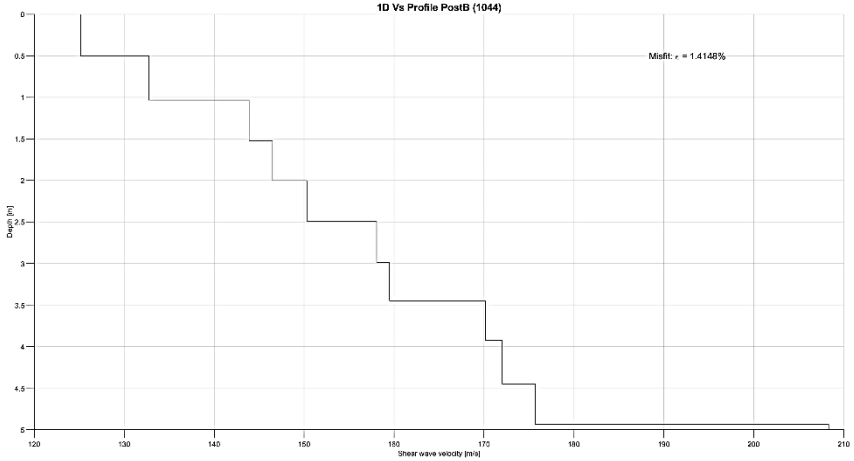


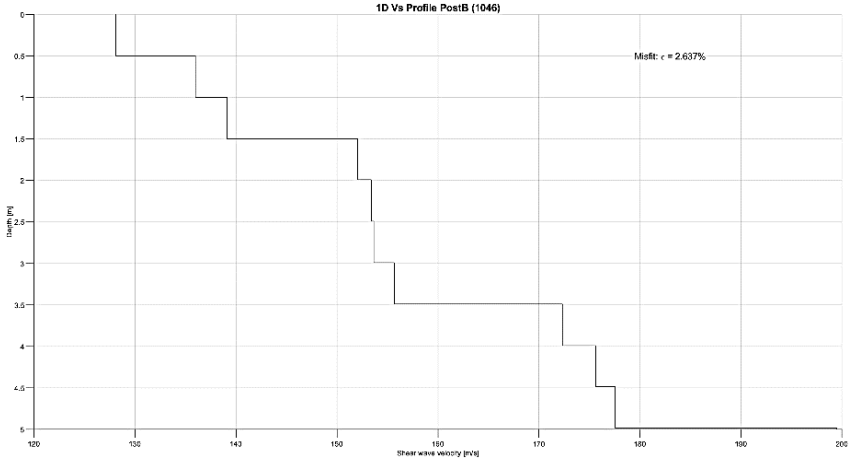


PostB 10 *passes*

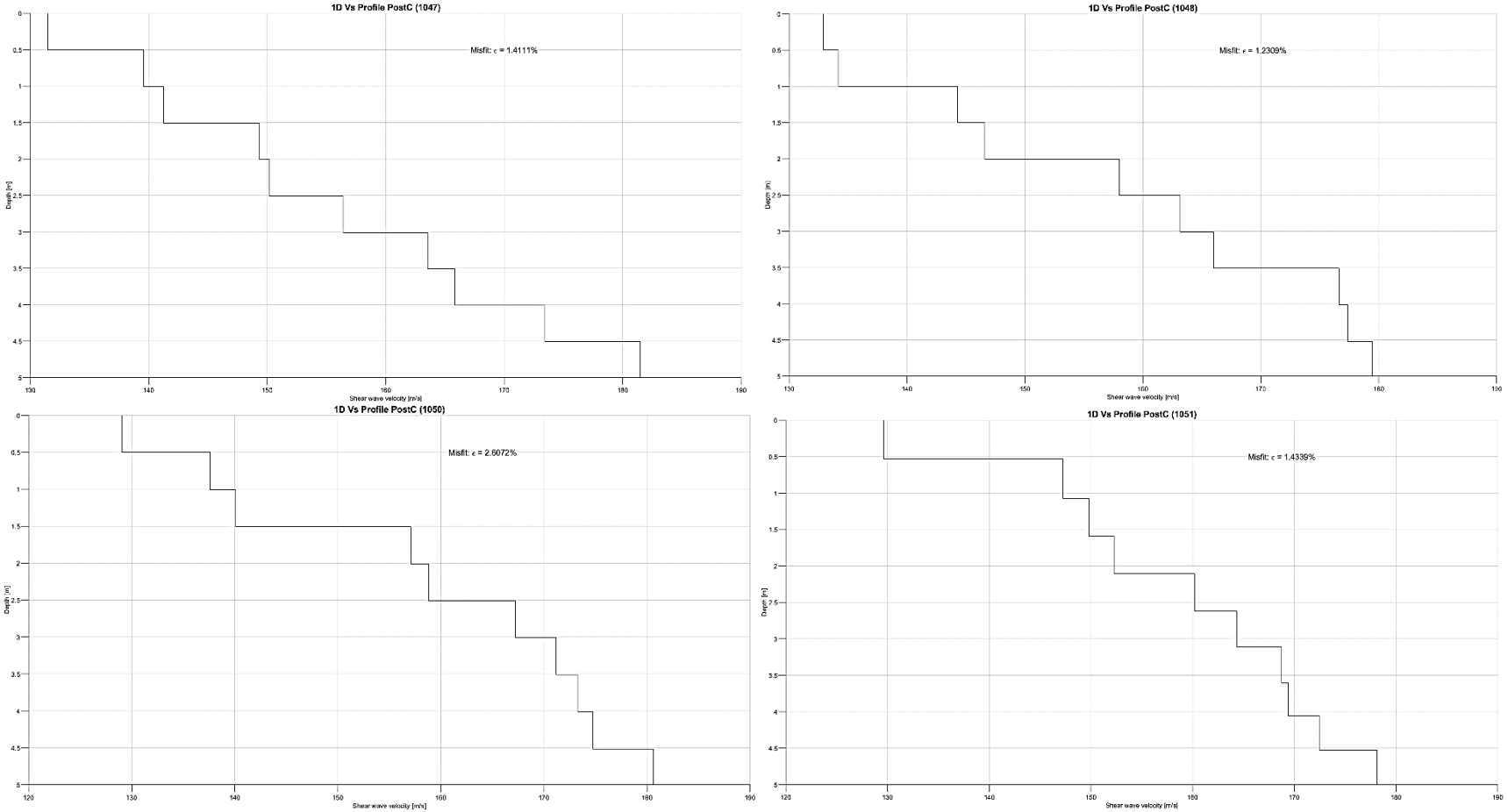




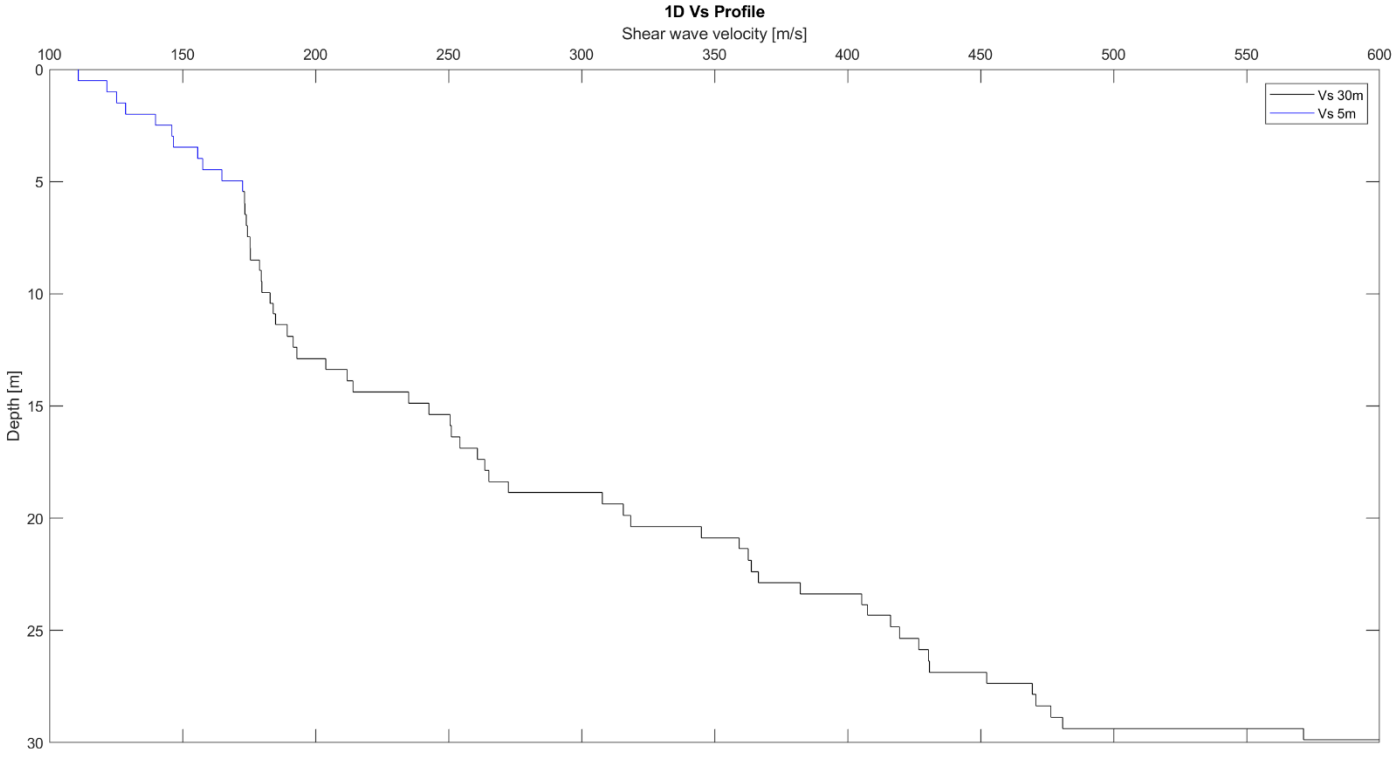




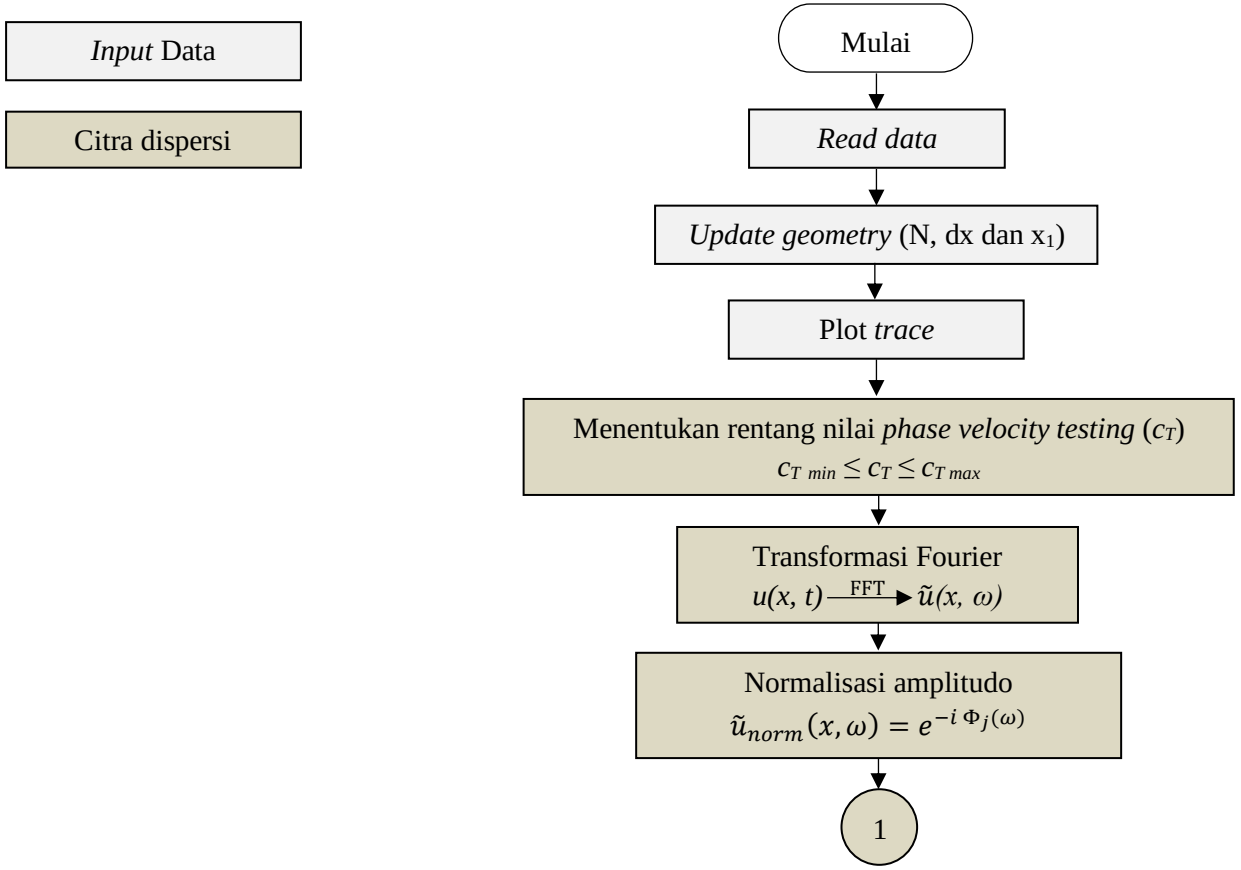
PostC 30 *passes*

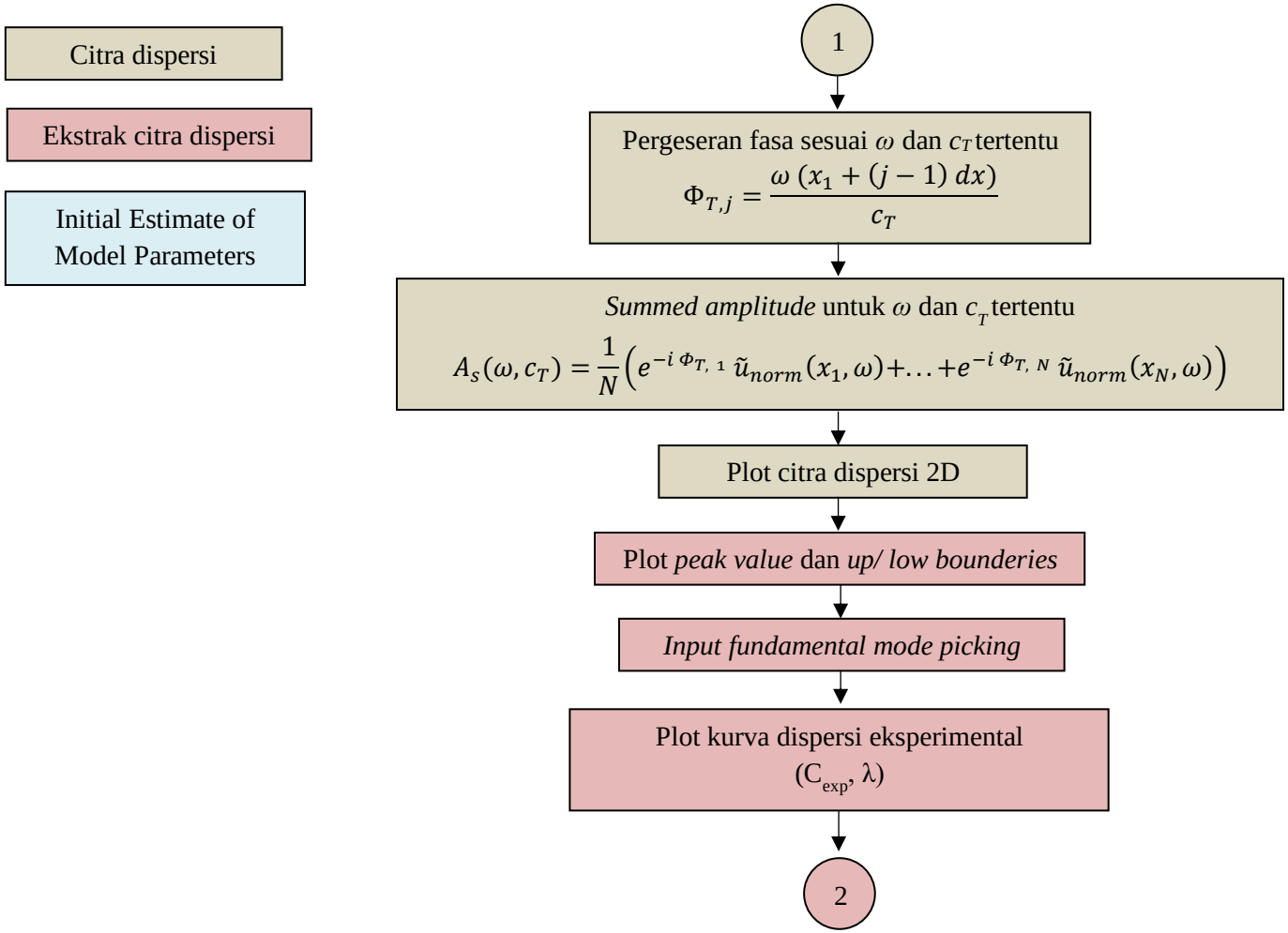


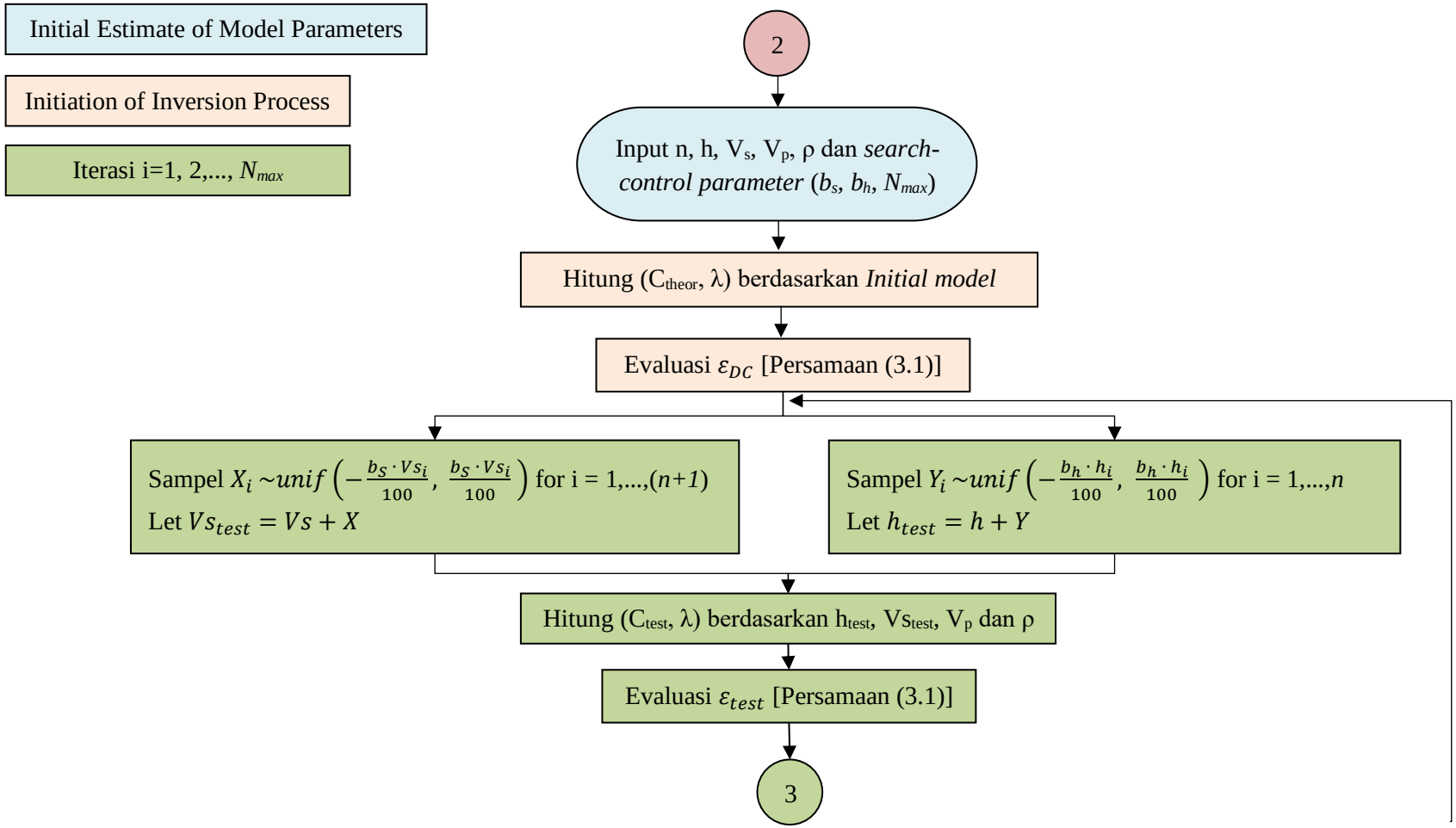
Overlay Vs_5 dan Vs_{30}



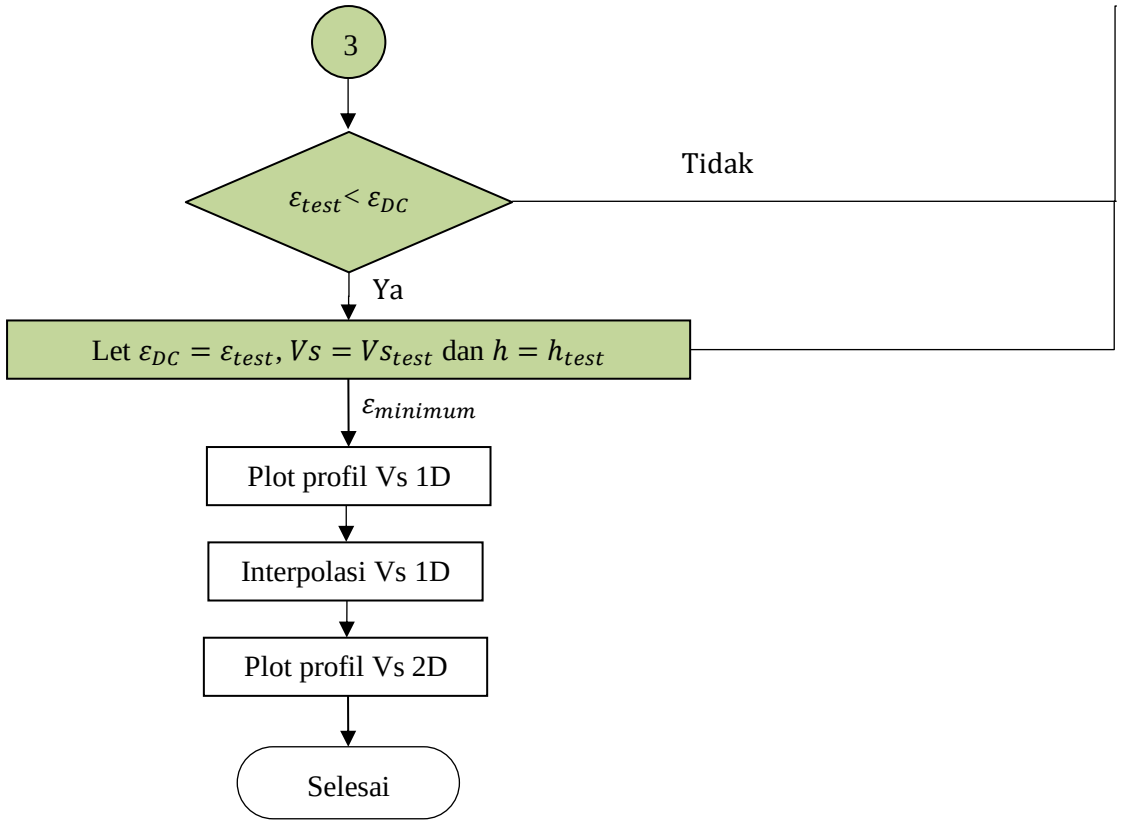
LAMPIRAN 4 *Program Workflow*




Citra dispersi
Ekstrak citra dispersi
Initial Estimate of Model Parameters
1
Pergeseran fasa sesuai ω dan c_T tertentu
$\Phi_{T,j} = \frac{\omega\,(x_1 + (j-1)\,dx)}{c_T}$
Summed amplitude untuk ω dan c_T tertentu
$A_s(\omega, c_T) = \frac{1}{N}\left(e^{-i\,\Phi_{T,\,1}}\,\tilde{u}_{norm}(x_1,\omega) + \ldots + e^{-i\,\Phi_{T,\,N}}\,\tilde{u}_{norm}(x_N,\omega)\right)$
Plot citra dispersi 2D
Plot *peak value* dan *up/ low bounderies*
Input fundamental mode picking
Plot kurva dispersi eksperimental
(C_{exp}, λ)
2


Initial Estimate of Model Parameters
Initiation of Inversion Process
Iterasi i=1, 2,..., N_{max}
2
Input n, h, V_s, V_p, ρ dan *search-control parameter* (b_s, b_h, N_{max})
Hitung (C_{theor}, λ) berdasarkan *Initial model*
Evaluasi ε_{DC} [Persamaan (3.1)]
Sampel $X_i \sim unif\left(-\frac{b_S \cdot Vs_i}{100}, \frac{b_S \cdot Vs_i}{100}\right)$ for i = 1,...,(n+1)
Let $Vs_{test} = Vs + X$
Sampel $Y_i \sim unif\left(-\frac{b_h \cdot h_i}{100}, \frac{b_h \cdot h_i}{100}\right)$ for i = 1,...,n
Let $h_{test} = h + Y$
Hitung (C_{test}, λ) berdasarkan h_{test}, Vs_{test}, V_p dan ρ
Evaluasi ε_{test} [Persamaan (3.1)]
3

Iterasi i=1, 2,..., N_{max}



LAMPIRAN 5 Kurva Teoritis

Kurva teoritis terbentuk dari hasil kalkulasi *initial model* menggunakan algoritma *fast delta matrix.*

A. Notasi dan Parameter

1. Parameter Dispersi

k, ω	bilangan gelombang dan frekuensi
$c = \omega/k$	kecepatan fasa
$D(c, k)$	fungsi dispersi

2. Parameter Model Lapisan

$i = 1,2, \dots, n$	Indeks lapisan
$i = 0$	Indeks atas lapisan *half-space* (jika ada)
$\ell = n + 1$	Indeks bawah lapisan *half-space* (jika ada)
α_i, β_i	Kecepatan gelombang P dan S lapisan ke-i
$\rho_i, \mu_i = \rho_i \beta_i^2$	Densitas dan rigiditas lapisan ke-i
d_i	Ketebalan lapisan ke-i

$\gamma_i = \beta_i^2/c^2$

$t_i = (2 - c^2/\beta_i^2)$

3. *Layer Eigenfunctions*

	$c < \alpha_i (c < \beta_i)$	$c > \alpha_i (c > \beta_i)$
r_i	$(1 - c^2/\alpha_i^2)^{1/2}$	$i(c^2/\alpha_i^2 - 1)^{1/2} = i\bar{r}_i$
s_i	$(1 - c^2/\beta_i^2)^{1/2}$	$i(c^2/\beta_i^2 - 1)^{1/2} = i\bar{s}_i$

$C_{\alpha_i}(k)$	$\cosh(kr_i d_i)$	$\cos(k\bar{r}_i d_i)$
$S_{\alpha_i}(k)$	$\sinh(kr_i d_i)$	$i \sin(k\bar{r}_i d_i)$
$C_{\beta_i}(k)$	$\cosh(ks_i d_i)$	$\cos(k\bar{s}_i d_i)$
$S_{\beta_i}(k)$	$\sinh(\mathrm{ks_i d_i})$	$i \sin(k\bar{s}_i d_i)$

B. Elemen *Fast Delta Matrix*

Di definisikan

$\varepsilon_i = \rho_{i+1}/\rho_i;\ \eta_i = 2(y_i - \varepsilon_i \gamma_{i+1})$

dan

$a_i = \varepsilon_i + \eta_i;\ a_i' = a_i - 1;\ b_i = 1 - \eta_i;\ b_i' = b_i - 1.$

Serta $a_i' + b_i = a_i + b_i' = a_i b_i - a_i' b_i' = \varepsilon_i$.

$\bar{T}_{11} = ab$

$\bar{T}_{12} = aa'$

$\bar{T}_{13} = 0$

$\bar{T}_{14} = 0$

$\bar{T}_{15} = bb'$

$\bar{T}_{16} = a'b'$

$\bar{T}_{21} = ab' C_\alpha C_\beta - a'b(S_\alpha/r)(S_\beta/s)$

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$\bar{T}_{22} = a^2 C_\alpha C_\beta - a'^2(S_\alpha/r)(S_\beta/s)$

$\bar{T}_{23} = \varepsilon C_x(S_\beta/s)$

$\bar{T}_{24} = -\varepsilon(S_\alpha/r)C_\beta$

$\bar{T}_{25} = b'^2 C_\alpha C_\beta - b^2(S_\alpha/r)(S_\beta/s)$

$$\vec{T}_{26} = \bar{T}_{21}$$

$$\bar{T}_{31} = ab'C_{\alpha}(sS_{\beta}) - a'b(S_{\alpha}/r)C_{\beta}$$

$$\vec{T}_{32} = a^2C_{\alpha}(sS_{\beta}) - a'^2(S_{\alpha}/r)C_{\beta}$$

$$\bar{T}_{33} = \varepsilon C_{\alpha}C_{\beta}$$

$$\bar{T}_{34} = -\varepsilon(S_{\alpha}/r)(sS_{\beta})$$

$$\bar{T}_{35} = b'^2C_{\alpha}(sS_{\beta}) - b^2(S_{\alpha}/r)C_{\beta}$$

$$\vec{T}_{36} = \bar{T}_{31}$$

$$\bar{T}_{41} = -ab'(rS_{\alpha})C_B + a'bC_x(S_{\beta}/s)$$

$$\bar{T}_{42} = -a^2(rS_{\alpha})C_{\beta} + a'^2C_a(S_{\beta}/s)$$

$$\bar{T}_{43} = -\varepsilon(rS_{\alpha})(S_{\beta}/s)$$

$$\vec{T}_{44} = \varepsilon C_{\alpha}C_{\beta}$$

$$\bar{T}_{45} = -b'^2(rS_{\alpha})C_{\beta} + b^2C_{\alpha}(S_{\beta}/s)$$

$$\vec{T}_{46} = \vec{T}_{41}$$

$$\bar{T}_{51} = -ab'(rS_{\alpha})(sS_{\beta}) + a'bC_{\alpha}C_B$$

$$\bar{T}_{52} = -a^2(rS_{\alpha})(sS_{\beta}) + a'^2C_{\alpha}C_B$$

$$\bar{T}_{53} = -\varepsilon(rS_{\alpha})C_{\beta}$$

$$\bar{T}_{54} = \varepsilon(rS_{\beta})C_{\alpha}$$

$$\bar{T}_{55} = -b'^2(rS_{\alpha})(sS_{\beta}) + b^2C_{\alpha}C_{\beta}$$

$$\vec{T}_{56} = \vec{T}_{51}$$

$$\bar{T}_{61} = a'b'$$

$$\bar{T}_{62} = aa'$$

$\bar{T}_{63} = 0$

$\bar{T}_{64} = 0$

$\bar{T}_{65} = bb'$

$\vec{T}_{66} = ab$

$$\bar{U}' = \mu_1^2 \begin{bmatrix} 2t_1 & -t_1^2 & 0 & 0 & -4 & 2t_1 \end{bmatrix} \qquad \bar{V} = \begin{bmatrix} 0 \\ 1 \\ s_\ell \\ -r_\ell \\ -r_\ell s_\ell \\ 0 \end{bmatrix}$$

C. Algoritma *Fast Delta Matriks*

Algoritma ini mirip dengan algoritma *Fast Schwab-Knopoff*, kecuali bahwa determinan dihitung menggunakan *delta matrix formalism* daripada *Knopoff decomposition*. Algoritma yang dihasilkan secara lebih sederhana dan sekitar 12 persen lebih efisien

Algoritma ini dinyatakan dalam hal vektor baris tunggal X dengan enam komponen. Hanya lima yang benar-benar diperlukan, dan ini sesuai dengan versi algoritma yang 'dikurangi'.

Faktorisasi yang dioptimalkan untuk komputasi numerik dinyatakan dalam hal parameter p_a, q_a, y_b, z_b $(a = 1,2,3,4; b = 1,2)$. Perhatikan bahwa tidak ada faktor yang dihasilkan yang mengandung $C_\alpha^2, S_\alpha^2, C_\beta^2$, atau S_β^2 yang akan menimbulkan masalah ketidakstabilan. Misalkan

$$X_i = [x_1, x_2, \dots, x_6] \qquad X_{i+1} = [\hat{x}_1, \hat{x}_2, \dots, \hat{x}_6]$$

Pada setiap iterasi, $x_6 = x_1$ (dan $\hat{x}_6 = \hat{x}_1$), jadi mengurangi istilah-istilah ini dapaat mengurangi algoritma. Variabel-variabel ini dituliskan di sini hanya demi kelengkapan.

1) Menginisialisasi:

$X_1 = \mu_1^2\ [2t_1 \quad -t_1^2 \quad 0 \quad 0 \quad -4 \quad 2t_1]; \qquad t_1 = 2 - c^2/\beta_1^2$

2) Rekursi Lapisan: (iterasi untuk $i = 1,2, \dots, n$)

$p_1 = C_\beta x_2 + sS_\beta x_3\ q_1 = C_\alpha p_1 - rS_\alpha p_2$

$p_2 = C_\beta x_4 + sS_\beta x_5\ q_2 = -\frac{1}{r}S_x p_3 + C_\alpha p_4$

$p_3 = \frac{1}{s}S_\beta x_2 + C_\beta x_3\ q_3 = C_x p_3 - rS_a p_4$

$p_4 = \frac{1}{S}S_\beta x_4 + C_\beta x_5\ q_4 = -\frac{1}{r}S_\alpha p_1 + C_\alpha p_2$

$y_1 = a'x_1 + aq_1$

$y_2 = ax_1 + a'q_2$

$z_1 = bx_1 + b'q_1$

$z_2 = b'x_1 + bq_2$

$\hat{x}_1 = b'y_1 + by_2$

$\hat{x}_2 = ay_1 + a'y_2$

$\hat{x}_3 = \varepsilon q_3$

$\hat{x}_4 = \varepsilon q_4$

$\hat{x}_5 = b'z_1 + bz_2$

$\hat{x}_6 = az_1 + a'z_2 = \hat{x}_1$

3) Fungsi dispersi : $D(c,k) = \hat{x}_2 + s_\ell \hat{x}_3 - r_\ell(\hat{x}_4 + s_l \hat{x}_5)$.