

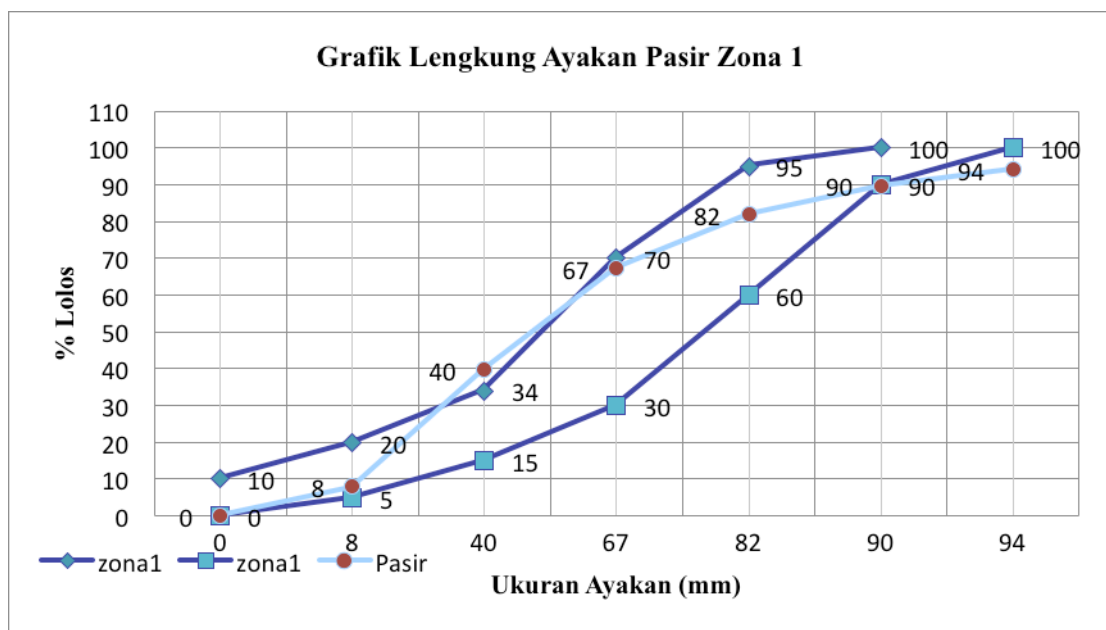
LAMPIRAN

1. Data Hasil Analisis Agregat Halus

a. Analisis Gradasi

Lubang Saringan		Pasir			
no	Mm	Tertinggal Gram	%	%Kumulatif Tertinggal	Lolos
3"	76.2	-	-	-	-
2.5"	63.5	-	-	-	-
2"	50.8	-	-	-	-
1.5"	38.1	-	-	-	-
1"	25.4	-	-	-	-
3/4"	19.1	-	-	-	-
1/2"	12.7	-	-	-	-
3/8"	9.5	-	-	-	100
4	4.76	56.86	5.793	5.793	94.207
8	2.38	43.48	4.430	10.224	89.776
16	1.19	77.42	7.888	18.112	81.888
20	0.59	143.91	14.663	32.775	67.225
50	0.297	269.31	27.440	60.215	39.785
100	0.149	312.96	31.888	92.103	7.897
200	0.075	77.51	7.897	100.000	0.000
Pan		11.27	-	-	-
Σ =		981.45	100	319.222	

$$\begin{aligned}
 \text{Modulus halus pasir} &= \frac{\Sigma \% \text{ yang tertahan ayakan no } 3/8" \text{ sampai no } 100}{100} \\
 &= \frac{319,222}{100} = 3,1922
 \end{aligned}$$



b. Pemeriksaan Kadar Air

Nomor Talam :			A	B
1	Berat Talam + Contoh basah	(gr)	513.4	536.4
2	Berat Talam + Contoh kering	(gr)	511.5	534.5
3	Berat Air = (1)-(2)	(gr)	1.9	1.9
4	Berat Talam	(gr)	74.8	74.4
5	Berat Contoh Kering = (2)-(4)	(gr)	436.7	460.1
6	Kadar Air = (3)/(5)	(%)	0.4351	0.4130
7	Kadar Air rata-rata	(%)	0.4240	

c. Berat Jenis dan Penyerapan Agregat

NOMOR CONTOH			A
Berat benda uji kering permukaan jenuh	500	(gr)	500
Berat benda uji kering oven	Bk	(gr)	496.9
Berat piknometer + air	B	(gr)	658.2
Berat piknometer + benda uji (ssd) + air (pd suhu kamar)	Bt	(gr)	965.6

NOMOR CONTOH		A
Berat Jenis Curah (Bulk Specific Gravity)	$Bk/(B+500-Bt)$	2.580
Berat Jenis Kering Permukaan Jenuh (Bulk Specific Gravity Saturated Surface Dry)	$500/(B+500-Bt)$	2.596
Berat Jenis Semu Apparent Specific Gravity)	$Bk/(B+Bk-Bt)$	2.622
Penyerapan (%) (Absorption)	$(500-Bk)/Bk \times 100\%$	0.624

d. Berat Isi Agregat

NO	Keterangan	Satuan		
1	Berat takaran	(gr)	1059.2	1059.2
2	Berat takaran + air	(gr)	3093.0	3093
3	Berat air = (2)-(1)	(gr)	2033.8	2033.8
4	Volume air = (3)/(1)	(cc)	1.9201	1.9201
	CARA		RODDED	SHOVELED
5	Berat Takaran	(gr)	1059.2	1059.2
6	Berat takaran + benda uji	(gr)	4394.4	4066.6
7	Berat benda uji = (6)-(5)	(gr)	3335.2	3007.4
8	Berat isi agregat halus = (7)/(4)	(gr/cc)	1736.9672	1566.2494
9	Berat isi agregat halus rata-rata	(gr/cc)	1651.6083	

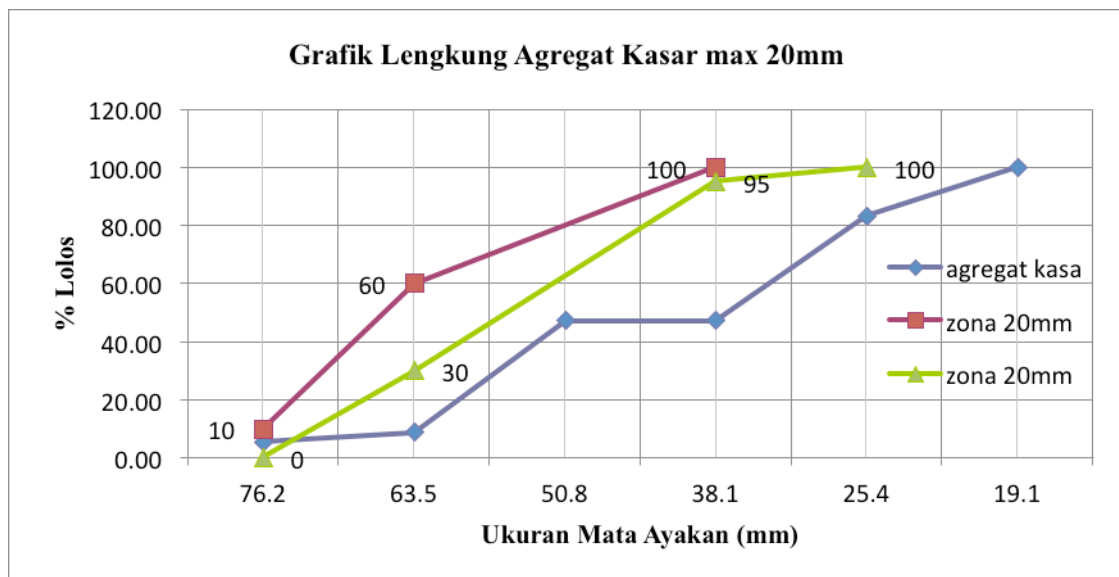
2. Data Hasil Analisis Agregat Kasar (Batu Bata)

a. Analisis Gradasi

Lubang Saringan		Limbah Batu Bata			
		Tertinggal		%Kumulatif	
NO	mm	gram	%	Tertinggal	Lolos
3"	76.2	-	-	-	100
2.5"	63.5	-	-	-	100
2"	50.8	-	-	-	100
1.5"	38.1	-	-	-	100
1"	25.4	1680	16.80	16.80	83.20
0.75"	19.1	3600	36.00	52.80	47.20
0.5"	12.7	0	0.00	52.80	47.20
0.375"	9.5	3840	38.40	91.20	8.80
4	4.76	320	3.20	94.40	5.60
8	2.38	560	5.60	100.00	0.00
16	1.19	-	-	100.00	0
20	0.85	-	-	100.00	0
50	0.297	-	-	100.00	0
100	0.149	-	-	100.00	0
200	0.075	-	-	100.00	0
Pan		-	-	-	-
$\Sigma =$		10000	100.0	908.00	

$$\text{Modulus halus agregat kasar} = \frac{\Sigma \% \text{ yang tertahan ayakan no } 3/4'' + 3/8'' \text{ sampai no } 100}{100}$$

$$= \frac{908}{100} = 9,08$$



b. Pemeriksaan Kadar Air

Nomor Talam :			A	B
1	Berat Talam + Contoh basah	(gr)	734.6	682.6
2	Berat Talam + Contoh kering	(gr)	719.5	676.5
3	Berat Air = (1)-(2)	(gr)	15.1	6.1
4	Berat Talam	(gr)	74.4	74.8
5	Berat Contoh Kering = (2)-(4)	(gr)	645.1	601.7
6	Kadar Air = (3)/(5)	(%)	2.3407	1.0138
7	Kadar Air rata-rata	(%)	1.6773	

c. Berat Jenis dan Penyerapan Agregat

Nomor Contoh			A	B	C	D	E
Berat benda uji kering permukaan jenuh	Bj	(gr)	648.8	644	650.4	647.6	630.8
Berat benda uji kering oven	Bk	(gr)	500	500	500	500	500
Berat benda uji dalam air	Ba	(gr)	293.5	291	293	295	286

Nomor Contoh		A	B	C	D	E
Berat Jenis Curah (Bulk Specific Gravity)	Bk/(Bj-Ba)	1.407	1.416	1.399	1.418	1.450
Berat Jenis Kering Permukaan Jenuh (Bulk Specific Gravity Saturated Surface Dry)	Bj/(Bj-Ba)	1.826	1.824	1.820	1.837	1.829
Berat Jenis Semu Apparent Specific Gravity)	Bk/(Bk-Ba)	2.421	2.392	2.415	2.439	2.336
Penyerapan (%) (Absorption)	(Bj-Bk)/Bkx100%	29.76	28.80	30.08	29.52	26.16
Rata-rata Penyerapan (%)		28.864				

d. Berat Isi Agregat

NO	Keterangan	Satuan		
1	Berat takaran	(gr)	1059.2	1059.2
2	Berat takaran + air	(gr)	3093	3093
3	Berat air = (2)-(1)	(gr)	2033.8	2033.8
4	Volume air = (3)/(1)	(cc)	1.9201	1.9201
	CARA		RODDED	SHOVELED
5	Berat Takaran	(gr)	1059.2	1059.2
6	Berat takaran + benda uji	(gr)	2735	2617.4
7	Berat benda uji = (6)-(5)	(gr)	1675.8	1558.2
8	Berat isi agregat halus = (7)/(4)	(gr/cc)	872.7541	811.5082
9	Berat isi agregat kasar rata-rata	(gr/cc)	842.1312	

3. Data Hasil Mix Design

NO	URAIAN	TABEL / GRAFIK	NILAI
1	Kuat tekan yang disyaratkan (2 HR, 5%)	Ditetapkan	22,5 Mpa
2	Deviasi standar	Diketahui	-
3	Nilai Tambah (Margin)	(K=1,64) 1,64*(2)	12 Mpa
4	Kuat tekan rata2 yg ditargetkan	(1) + (3)	34,5 Mpa
5	Jenis Semen	Ditetapkan	Normal (Tipe I)
6	Jenis Agregat Kasar	Ditetapkan	Batu Bata
	Jenis Agregat Halus	Ditetapkan	Pasir
7	Faktor Air semen Bebas	Tabel 2, Grafik 1/2	0,52
8	Faktor air semen Maksimum	Ditetapkan	0,6

9	Slump	Ditetapkan	60-180 mm	
10	Ukuran Agregat Maksimum	Ditetapkan	20 mm	
11	Kadar Air Bebas	TABEL 6	205	kg/m ³
12	Jumlah semen	(11) : (7)	394,231	kg/m ³
13	Jumlah Semen Maksimum	Ditetapkan	-	
14	Jumlah Semen Minimum	Ditetapkan	325 kg/m ³	
15	FAS yg disesuaikan	-	-	
16	Susunan besar butir agregat halus	Grafik 3 - 6	Zona 1	
17	Persen agregat halus	Grafik 13 - 15	54 %	
18	Berat Jenis Relatif Agregat (SSD)	Diketahui	2,544	kg/m ³
19	Berat isi beton	Grafik 16	2312,5	kg/m ³
20	Kadar agregat gabungan	(19) - (11) - (12)	1713,269	kg/m ³
21	Kadar agregat halus	(17) * (20)	925,165	kg/m ³
22	Kadar agregat kasar	(20) - (21)	788,104	kg/m ³
Banyaknya Bahan (Teoritis)		Semen (kg)	Air (kg/lt)	Ag. Halus (kg)
Tiap m ³ dg ketelitian 5kg (Teoritis)		394,23	205	925,165
Tiap campuran uji 0,03082 m ³		12,15	6,32	28,51
Tiap m ³ dg ketelitian 5kg (Aktual)		394,23	421,11	923,316
Tiap campuran uji 0,03082 m ³		12,1502	12,9786	28,4566
Proporsi (Teoritis) (1/3)		1	0,52	2,35
Proporsi (Aktual)		1	1,07	2,34

4. Data Hasil Uji Kuat Tekan Silinder

Dimensi Silinder Beton (15x30) cm :

Luas Penampang : $A = 17662,5 \text{ mm}^2$

Volume : $V = 5,299 \times 10^{-3} \text{ m}^3$

Umur Beton : 7 Hari, Koreksi Umur Beton : 0,65

Benda Uji	Berat kg	Berat Isi kg/m ³	Berat Isi Rata-Rata kg/m ³	P _{max} kN	Kuat Tekan 7 hari N/mm ²	Kuat Tekan 28 hari N/mm ²	Kuat Tekan Rata-Rata N/mm ²
1	10,45	1972,1632	1969,0179	144	8,1529	12,5429	10,8008
2	10,50	1981,5994		103	5,8316	8,9716	
3	10,35	1953,2909		125	7,0771	10,8879	

Silinder Kontrol Benda Uji

Benda Uji	Pmax (kN)	Kuat Tekan 28 hari (N/mm ²)
B3	197,5	11,17
B4	219,5	12,42
B5	208,5	11,79
B6	251,5	14,23

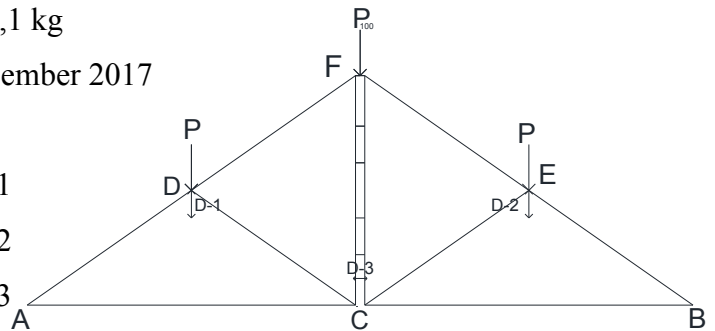
5. Data Hasil Uji Kekakuan Kuda-Kuda

a. Kuda-Kuda Beton Komposit dengan Sambungan Grouting Beban Vertikal Simetris

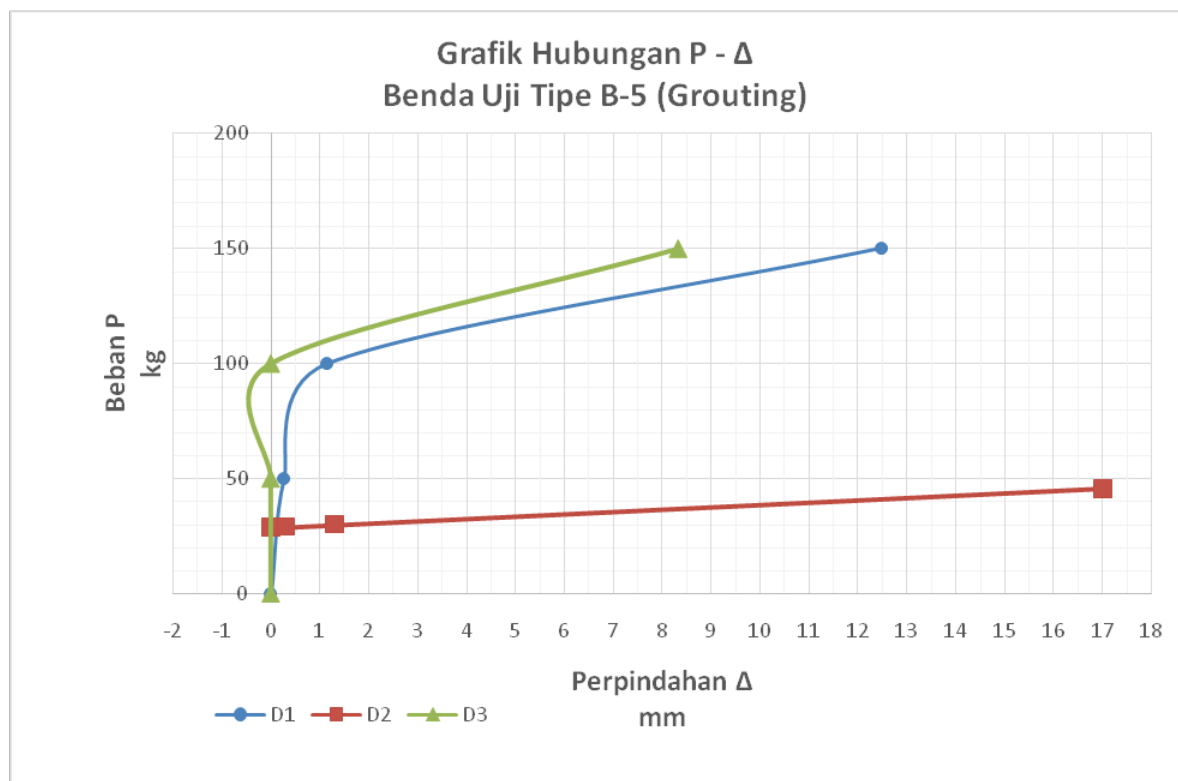
Kode Benda Uji = B-5

Berat Benda Uji = 133,1 kg

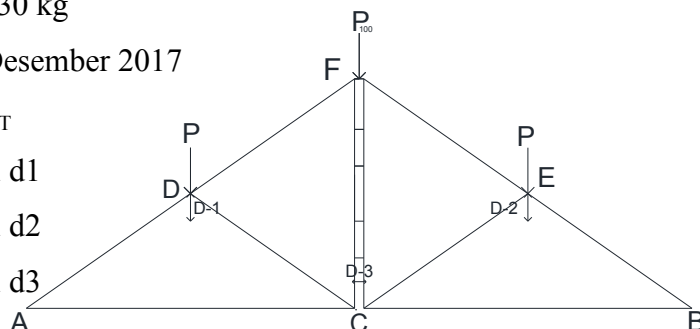
Tangga Pengujian = Desember 2017

Beban Tetap 100 kg = P_T Perpindahan Vertikal Titik D = $\Delta d1$ Perpindahan Vertikal Titik E = $\Delta d2$ Perpindahan Horizontal Titik C = $\Delta d3$ 

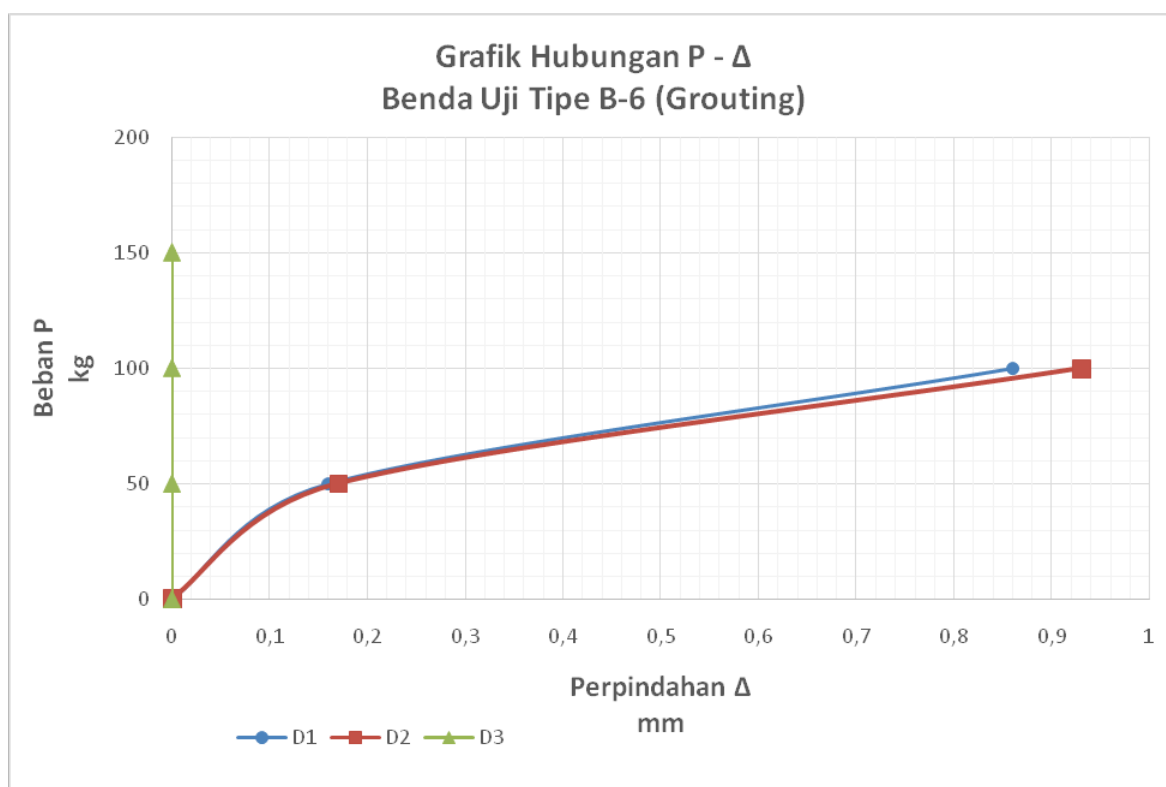
No	P_i	$d1$	$d2$	$d3$	$\Delta d1$	$\Delta d2$	$\Delta d3$
	kg	mm	mm	mm	mm	mm	mm
1	0	37,76	28,53	0	0	0	0
2	50	38,02	28,84	0	0,26	0,31	0
3	100	38,91	29,84	0	1,15	1,31	0
4	150	50,22	45,53	-8,31	12,46	17	8,31



Kode Benda Uji = B-6
 Berat Benda Uji = 130 kg
 Tangga Pengujian = Desember 2017
 Beban Tetap 100 kg = P_T
 Perpindahan Vertikal Titik D = $\Delta d1$
 Perpindahan Vertikal Titik E = $\Delta d2$
 Perpindahan Horizontal Titik C = $\Delta d3$



No	Pi	d1	d2	d3	$\Delta d1$	$\Delta d2$	$\Delta d3$
	Kg	mm	mm	mm	mm	mm	mm
1	0	25,12	22,18	0	0	0	0
2	50	25,28	22,35	0	0,16	0,17	0
3	100	25,98	23,11	0	0,86	0,93	0



b. Kuda-Kuda Beton Komposit dengan Sambungan Grouting Beban Vertikal Tidak Simetris

Kode Benda Uji = B-3

Berat Benda Uji = 126,55 kg

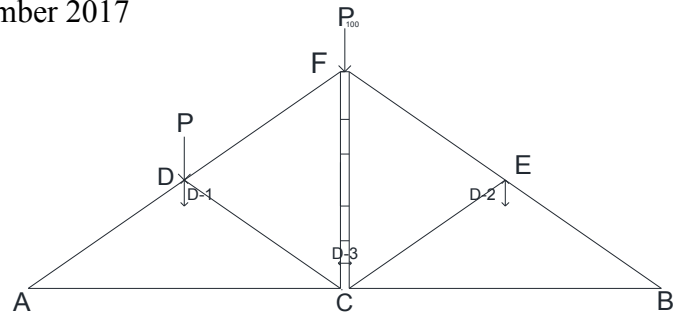
Tangga Pengujian = Desember 2017

Beban Tetap 100 kg = P_T

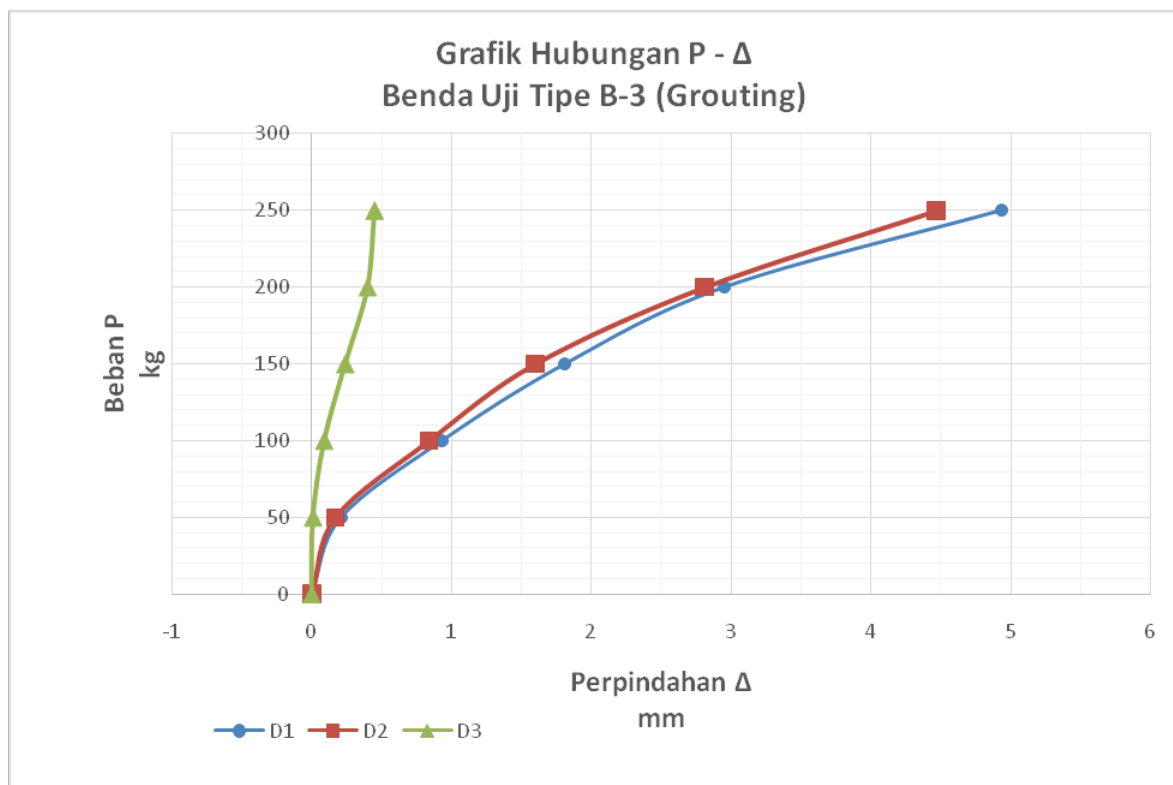
Perpindahan Vertikal Titik D = $\Delta d1$

Perpindahan Vertikal Titik E = $\Delta d2$

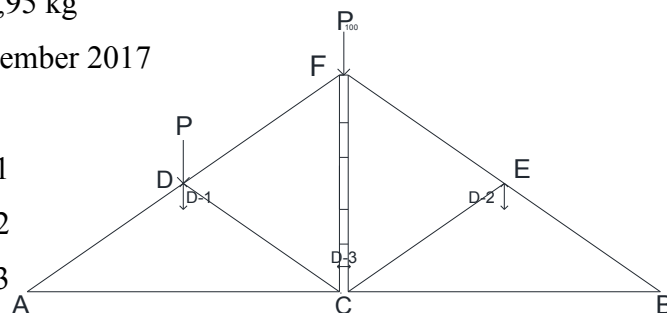
Perpindahan Horizontal Titik C = $\Delta d3$



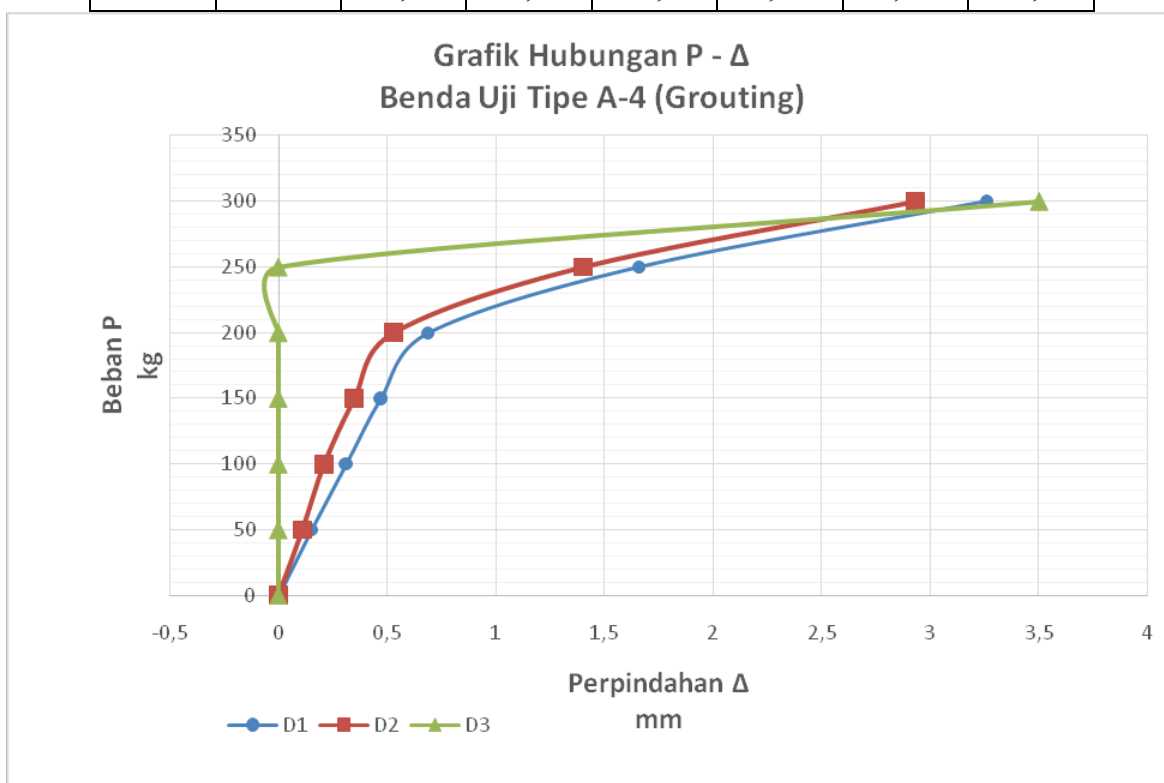
No	Pi	d1	d2	d3	$\Delta d1$	$\Delta d2$	$\Delta d3$
	Kg	mm	mm	mm	mm	mm	mm
1	0	26,8	17,56	0	0	0	0
2	50	27,01	17,73	-0,01	0,21	0,17	0,01
3	100	27,73	18,4	-0,09	0,93	0,84	0,09
4	150	28,61	19,16	-0,24	1,81	1,6	0,24
5	200	29,75	20,37	-0,4	2,95	2,81	0,4
6	250	31,73	22,03	-0,45	4,93	4,47	0,45



Kode Benda Uji = B-4
 Berat Benda Uji = 130,95 kg
 Tangga Pengujian = Desember 2017
 Beban Tetap 100 kg = P_T
 Perpindahan Vertikal Titik D = $\Delta d1$
 Perpindahan Vertikal Titik E = $\Delta d2$
 Perpindahan Horizontal Titik C = $\Delta d3$



No	Pi	d1	d2	d3	$\Delta d1$	$\Delta d2$	$\Delta d3$
	Kg	mm	mm	mm	mm	mm	mm
1	0	30,13	19,66	0	0	0	0
2	50	30,28	19,77	0	0,15	0,11	0
3	100	30,44	19,87	0	0,31	0,21	0
4	150	30,6	20,01	0	0,47	0,35	0
5	200	30,82	20,19	0	0,69	0,53	0
6	250	31,79	21,06	0	1,66	1,4	0
7	300	33,39	22,59	-3,5	3,26	2,93	-3,5



6. Perhitungan Beban Maksimum Teoritis yang Mampu ditahan Kuda-Kuda

Data Teknis

Kuat tekan beton	$= f'_c = 10,8 \text{ MPa}$
Kuat tarik beton	$= f'_{cr} = 0,57\sqrt{f'_c} = 1,873 \text{ MPa}$
Berat isi beton	$= 1969,018 \text{ kg/m}^3$
Elastisitas beton	$= E_c = W_c^{1,5} (0,043)\sqrt{f'_c} = 12346,812 \text{ MPa}$
Kuat tarik bambu (ftr)	$= f_{y_{bambu}} = 149,67 \text{ (Ummiati, 2009)}$
Kuat tekan bambu (ftk)	$= 35,10 \text{ Mpa (Feblin, 2011)}$
Alat sambung kuda-kuda	$= \text{Tulangan } \phi 10 \text{ mm}$
Jenis sambungan antar segmen	$= \text{Grouting}$
Sudut α	$= 35^\circ$

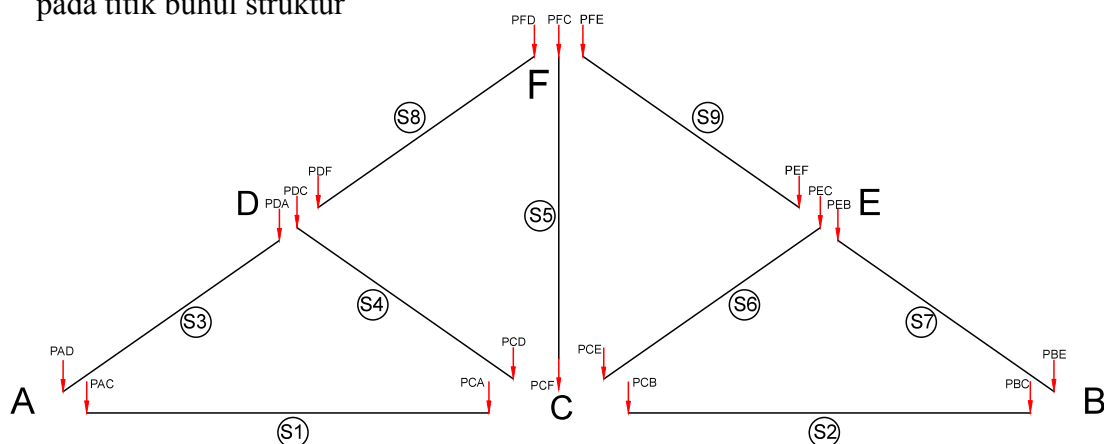
Untuk memperoleh beban maksimum tiap tipe pembebanan kuda-kuda beton tulangan bambu, dilakukan dengan tahap perhitungan sebagai berikut:

1. Hitung gaya batang akibat berat sendiri beton.
2. Hitung gaya batang akibat beban luar untuk semua tipe pengujian benda uji, dalam hal ini adalah P_T dan P sesuai rencana pengujian.
3. Hitung jumlah beban total maksimum untuk batang tarik dan tekan.
4. Hitung beban P_o yang ditahan batang sesuai kapasitas kuat tekan atau tarik bahan penyusun batang. Beton dan tulangan bambu pada batang tarik dan tekan.
5. Beban total maksimum batang tarik atau tekan terkecil menentukan beban P maks yang mampu ditahan.

Berikut ini ialah perhitungan beban maksimum teoritis

1. Hitung gaya batang akibat berat sendiri beton.

Beban mati akibat berat sendiri diasumsikan sebagai beban terpusat yang bekerja pada titik buhul struktur



No. Batang	Panjang (cm)	Luas Permukaan (cm ²)
1	150	8x8 = 64
2	150	8x8 = 64
3	82,25	8x8 = 64
4	63,74	8x8 = 64
5	100,93	8x16 = 128

No. Batang	Panjang (cm)	Luas Permukaan (cm ²)
6	63,74	8x8 = 64
7	82,25	8x8 = 64
8	63,33	8x8 = 64
9	63,33	8x8 = 64

Perhitungan beban terpusat yang bekerja

Luas Penampang $= A = 8 \text{ cm} \times 8 \text{ cm} = 64 \text{ cm}^2$

Berat Isi Beton $= \gamma_c = 1969,018 \text{ kg/m}^3$

Besar gaya Terpusat Per Batang $= P_{\text{batang}} = \gamma_c \times A \times L$

Besar gaya per Titik Buhul Per batang $P_{\text{joint}} = P_{\text{batang}}/2$

	Nama Beban Terpusat	No. Batang	Panjang (cm)	Besar Gaya (kg)	
PA	P _{AC}	1	150	9,4416	14,6187
	P _{AD}	3	82,25	5,1771	
PC	P _{CA}	1	150	9,4416	39,6133
	P _{CD}	4	63,74	4,0121	
	P _{CF}	5	100,93	12,7059	
	P _{CE}	6	63,74	4,0121	
	P _{CB}	2	150	9,4416	
PB	P _{BE}	7	82,25	5,1771	14,6187
	P _{BC}	2	150	9,4416	
PE	P _{EF}	9	63,33	3,9863	13,1755
	P _{EC}	6	63,74	4,0121	
	P _{EB}	7	82,25	5,1771	
PF	P _{FE}	9	63,33	3,9863	20,6785
	P _{FC}	5	100,93	12,7059	
	P _{FD}	8	63,33	3,9863	
PD	P _{DF}	8	63,33	3,9863	13,1755
	P _{DC}	4	63,74	4,0121	
	P _{DA}	3	82,25	5,1771	

Contoh Perhitungan :

$$\gamma_c = 1969,018 \text{ kg/m}^3 = 1,969,018 \times 10^{-3} \text{ kg/cm}^3$$

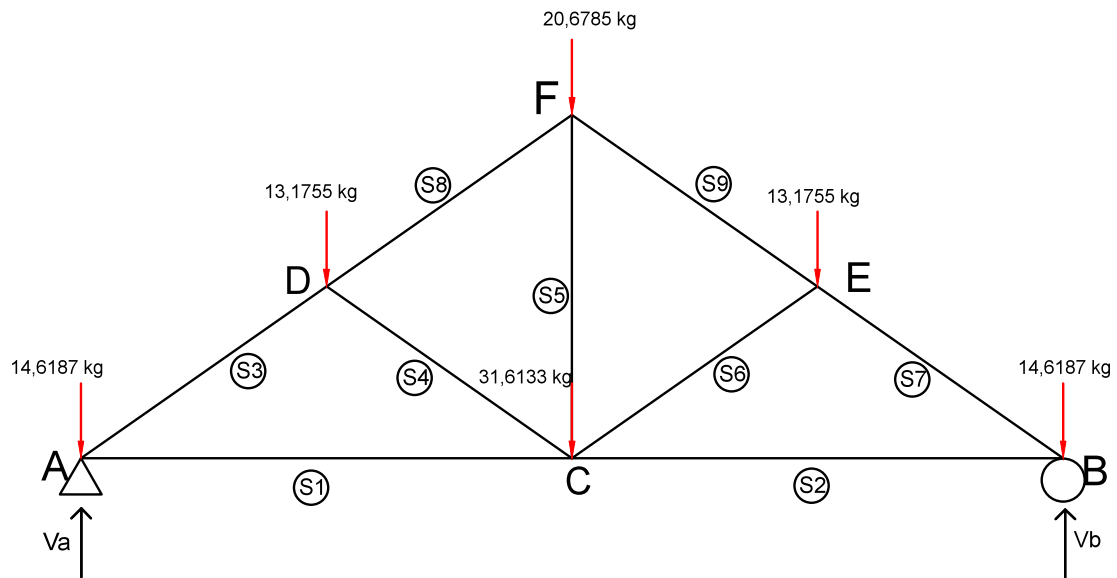
$$A_s = 128 \text{ cm}^2$$

$$L_5 = 100,93 \text{ cm}$$

$$P_{CF} = \frac{\gamma_c \times A_5 \times L_5}{2} = \frac{(2,3125 \times 10^{-3} \times 128 \times 100,93)}{2} = 12,7059 \text{ Kg}$$

$$P_C = P_{CA} + P_{CD} + P_{CF} + P_{CE} + P_{CB}$$

$$= 9,4416 + 4,0121 + 12,7059 + 4,0121 + 9,4416 = 39,6133 \text{ Kg}$$



Pemeriksaan ketentuan Statika

$$N = 2j - r$$

$$9 = 2 \cdot (6) - 3$$

$$9 = 12 - 3$$

$$9 = 9 \quad (\text{Statis Tertentu})$$

Berdasarkan perhitungan Beban Luar didapatkan:

$$P_A : 14,6187 \text{ kg}$$

$$P_B : 14,6187 \text{ kg}$$

$$P_C : 39,6133 \text{ kg}$$

$$P_F : 20,6785 \text{ kg}$$

$$P_E : 13,1755 \text{ kg}$$

$$P_D : 13,1755 \text{ kg} \quad +$$

$$\Sigma P : 115,8802 \text{ kg}$$

Perhitungan Reaksi Tumpuan

$$\Sigma M_A = 0$$

$$-V_B \cdot 300 + P_D \cdot 75 + P_F \cdot 150 + P_C \cdot 150 + P_E \cdot 225 + P_B \cdot 300 = 0$$

$$-300V_B + 13,1755 \cdot 75 + 20,6785 \cdot 150 + 39,6133 \cdot 150 + 13,1755 \cdot 225 + 14,6187 \cdot 300 = 0$$

$$V_B = \frac{17382,03}{-300}$$

$$V_B = 57,9401 \text{ Kg}$$

$$\Sigma M_B = 0$$

$$V_A \cdot 300 + P_A \cdot 300 + P_D \cdot 225 + P_F \cdot 150 + P_C \cdot 150 + P_E \cdot 75 = 0$$

$$-300V_B + 14,6187 \cdot 300 + 13,1755 \cdot 225 + 20,6875 \cdot 150 + 39,6133 \cdot 150 + 13,1755 \cdot 75 = 0$$

$$V_B = \frac{17382,03}{-300}$$

$$V_B = 57,9401 \text{ Kg}$$

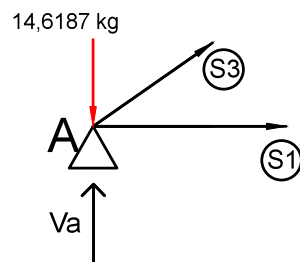
$$\Sigma V = 0$$

$$V_A + V_B = \Sigma P$$

$$57,9401 + 57,9401 = 115,8802 \text{ Kg}$$

$$115,8802 \text{ Kg} = 115,8802 \text{ Kg} \quad (\text{OK})$$

BUHUL A



$$\Sigma V = 0$$

$$-P_A + V_A + S3 \cdot \sin 35^\circ = 0$$

$$-14,6187 + 57,9401 + S3 \cdot 0,574 = 0$$

$$S3 = \frac{-43,3214}{0,574}$$

$$S3 = -75,473 \text{ Kg (tekan)}$$

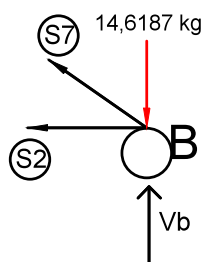
$$\Sigma H = 0$$

$$S1 - S3 \cdot \cos 35^\circ = 0$$

$$S1 - (75,473)(0,819) = 0$$

$$S1 = 61,812 \text{ Kg (tarik)}$$

BUHUL B



$$\Sigma V = 0$$

$$S7 \cdot \sin 35^\circ - P_B + V_B = 0$$

$$S7 \cdot 0,574 - 14,6187 + 57,9401 = 0$$

$$S7 = \frac{-43,3214}{0,574}$$

$$S7 = -75,473 \text{ Kg (tekan)}$$

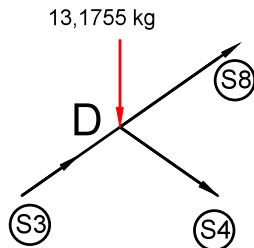
$$\Sigma H = 0$$

$$-S_2 + S_7 \cdot \cos 35^\circ = 0$$

$$-S_2 + (75,473)(0,819) = 0$$

$$S_2 = 61,812 \text{ Kg (tarik)}$$

BUHUL D



$$\Sigma V = 0$$

$$-P_D + S_3 \cdot \sin 35^\circ + S_8 \cdot \sin 35^\circ - S_4 \cdot \sin 35^\circ = 0$$

$$-13,1755 + (75,473)(0,574) + 0,574S_8 - 0,574S_4 = 0$$

$$0,574 S_8 - 0,574 S_4 = -30,1459 \quad \dots(1)$$

$$\Sigma H = 0$$

$$S_3 \cdot \cos 35^\circ + S_8 \cdot \cos 35^\circ + S_4 \cdot \cos 35^\circ = 0$$

$$(75,473)(0,819) + 0,819S_8 + 0,819S_4 = 0$$

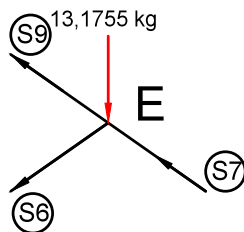
$$S_8 + S_4 = -75,473 \quad \dots(2)$$

Eliminasi (1) dan (2), didapatkan

$$S_4 = -11,4769 \text{ Kg (tekan)}$$

$$S_8 = -63,9961 \text{ Kg (tekan)}$$

BUHUL E



$$\Sigma V = 0$$

$$-P_E + S_9 \cdot \sin 35^\circ + S_7 \cdot \sin 35^\circ - S_6 \cdot \sin 35^\circ = 0$$

$$-13,1755 + (75,473)(0,574) + 0,574S_9 - 0,574S_6 = 0$$

$$0,574 S_9 - 0,574 S_6 = -30,1459 \quad \dots(1)$$

$$\Sigma H = 0$$

$$-S_7 \cdot \cos 35^\circ - S_6 \cdot \cos 35^\circ - S_9 \cdot \cos 35^\circ = 0$$

$$-(75,473)(0,819) - 0,819S_6 - 0,819S_9 = 0$$

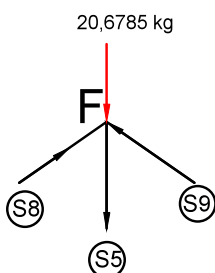
$$S_9 + S_6 = -75,473 \quad \dots(2)$$

Eliminasi (1) dan (2), didapatkan

$$S_6 = -11,4769 \text{ Kg (tekan)}$$

$$S_9 = -63,9961 \text{ Kg (tekan)}$$

BUHUL F



$$\Sigma V = 0$$

$$-P_F - S_5 + S_9 \cdot \sin 35^\circ + S_8 \cdot \sin 35^\circ = 0$$

$$-20,6785 + (63,9961)(0,574) + (63,9961)(0,574) - S_5 = 0$$

$$S_5 = 52,7891 \text{ Kg (tarik)}$$

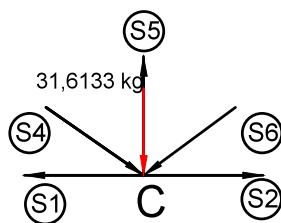
$$\Sigma H = 0$$

$$S8.\cos 35^\circ - S9.\cos 35^\circ = 0$$

$$(63,9961)(0,819) - (63,9961)(0,819) = 0$$

$$0 = 0 \quad (\text{OK})$$

BUHUL C



$$\Sigma V = 0$$

$$S5 - S4.\sin 35^\circ - S6.\sin 35^\circ - P_C = 0$$

$$52,7891 - (11,4769)(0,574) - (11,4769)(0,574) -$$

$$39,6133 = 0$$

$$0 = 0 \quad (\text{OK})$$

$$\Sigma H = 0$$

$$-S1 + S2 + S4.\cos 35^\circ - S6.\cos 35^\circ = 0$$

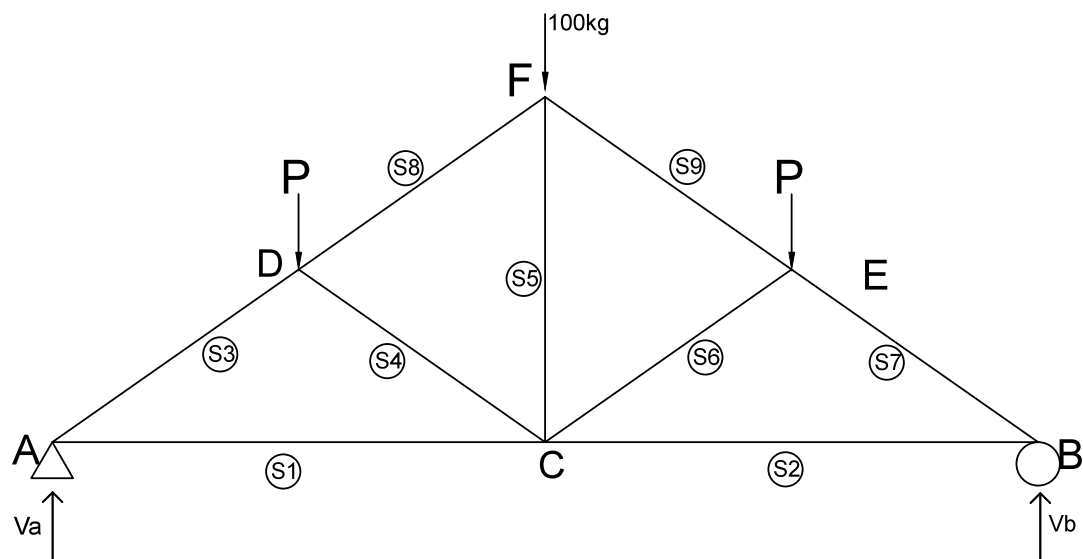
$$-61,812 + 61,812 + (11,4769)(0,819) -$$

$$(11,4759)(0,819) = 0$$

$$0 = 0 \quad (\text{OK})$$

2. Hitung gaya batang akibat beban luar untuk semua tipe pengujian benda uji, dalam hal ini adalah P_T , P , dan H sesuai rencana pengujian.

- Akibat Beban Luar Vertikal Simetris



Perhitungan Reaksi Tumpuan

$$\Sigma M_A = 0$$

$$-V_B.300 + P.225 + P_T.150 + P.75 = 0$$

$$-300V_B + P.225 + 100.150 + P.75 = 0$$

$$V_B = \frac{-300P - 15000}{-300}$$

$$V_B = 50 + P \text{ Kg}$$

$$\Sigma M_B = 0$$

$$V_A \cdot 300 - P \cdot 225 - P_T \cdot 150 - P \cdot 75 = 0$$

$$300V_A - P \cdot 225 - 100 \cdot 150 - P \cdot 75 = 0$$

$$V_B = \frac{300P + 15000}{300}$$

$$V_B = 50 + P \text{ Kg}$$

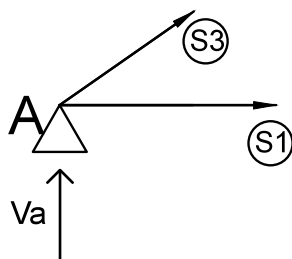
$$\Sigma V = 0$$

$$V_A + V_B = P_T + P + P$$

$$(50 + P) + (50 + P) = 100 + 2P \text{ Kg}$$

$$100 + 2P = 100 + 2P \text{ Kg} \quad (\text{OK})$$

BUHUL A



$$\Sigma V = 0$$

$$V_A + S3 \cdot \sin 35^\circ = 0$$

$$(50 + P) + S3 \cdot 0,574 = 0$$

$$S3 = \frac{-50 - P}{0,574}$$

$$S3 = -87,108 - 1,742P \text{ Kg (tekan)}$$

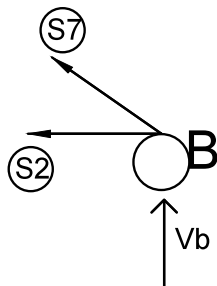
$$\Sigma H = 0$$

$$S1 - S3 \cdot \cos 35^\circ = 0$$

$$S1 - (-87,108 - 1,742P)(0,819) = 0$$

$$S1 = 71,341 + 1,427P \text{ Kg (tarik)}$$

BUHUL B



$$\Sigma V = 0$$

$$V_B + S7 \cdot \sin 35^\circ = 0$$

$$S7 = \frac{-50 - P}{0,574}$$

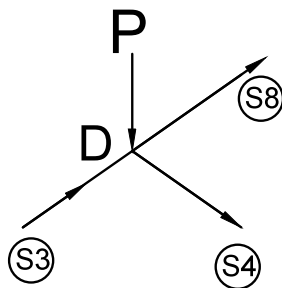
$$S7 = -87,108 - 1,742P \text{ Kg (tekan)}$$

$$\Sigma H = 0$$

$$-S2 + S7 \cdot \cos 35^\circ = 0$$

$$-S2 + (-87,108 - 1,742P)(0,819) = 0$$

$$S2 = 71,341 + 1,427P \text{ Kg (tarik)}$$

BUHUL D

$$\Sigma V = 0$$

$$-P + S3.\sin 35^\circ + S8.\sin 35^\circ - S4.\sin 35^\circ = 0$$

$$-P + (87,108 + 1,742 P)(0,574) + 0,574S8 - 0,574S4 = 0$$

$$0,574 S8 - 0,574 S4 = -50 \quad \dots(1)$$

$$\Sigma H = 0$$

$$S3.\cos 35^\circ + S8.\cos 35^\circ + S4.\cos 35^\circ = 0$$

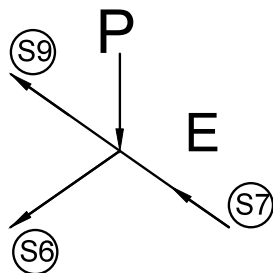
$$(87,108 + 1,742 P)(0,819) + 0,819S8 + 0,819S4 = 0$$

$$S8 + S4 = -87,108 - 1,742P \quad \dots(2)$$

Eliminasi (1) dan (2), didapatkan

$$S4 = -0,871P \text{ Kg (tekan)}$$

$$S8 = -87,108 - 0,871P \text{ Kg (tekan)}$$

BUHUL E

$$\Sigma V = 0$$

$$-P + S9.\sin 35^\circ + S7.\sin 35^\circ - S6.\sin 35^\circ = 0$$

$$-P + (87,108 + 1,742)(0,574) + 0,574S9 - 0,574S6 = 0$$

$$0,574 S9 - 0,574 S6 = -50 \quad \dots(1)$$

$$\Sigma H = 0$$

$$-S7.\cos 35^\circ - S6.\cos 35^\circ - S9.\cos 35^\circ = 0$$

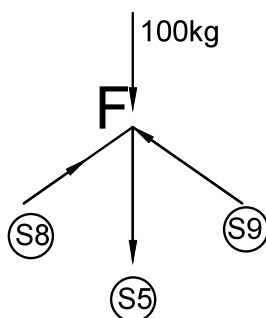
$$-(87,108 + 1,742)(0,819) - 0,819S6 - 0,819S9 = 0$$

$$S9 + S6 = -87,108 - 1,742P \quad \dots(2)$$

Eliminasi (1) dan (2), didapatkan

$$S6 = -0,871P \text{ Kg (tekan)}$$

$$S9 = -87,108 - 0,871P \text{ Kg (tekan)}$$

BUHUL F

$$\Sigma V = 0$$

$$-P_T - S5 + S9.\sin 35^\circ + S8.\sin 35^\circ = 0$$

$$-100 - S5 + (87,108 + 0,871P)(0,574) + (87,108 + 0,871P)(0,574) = 0$$

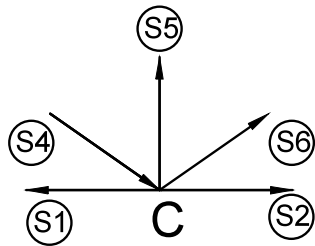
$$S5 = P \text{ Kg (tarik)}$$

$$\Sigma H = 0$$

$$S8.\cos 35^\circ - S9.\cos 35^\circ = 0$$

$$(87,108 + 0,871P)(0,819) - (87,108 + 0,871P)(0,819) = 0$$

$$0 = 0 \quad (\text{OK})$$

BUHUL C

$$\Sigma V = 0$$

$$S5 - S4 \cdot \sin 35^\circ - S6 \cdot \sin 35^\circ = 0$$

$$P - (0,871P)(0,574) - (0,871P)(0,574) = 0$$

$$0 = 0 \quad (\text{OK})$$

$$\Sigma H = 0$$

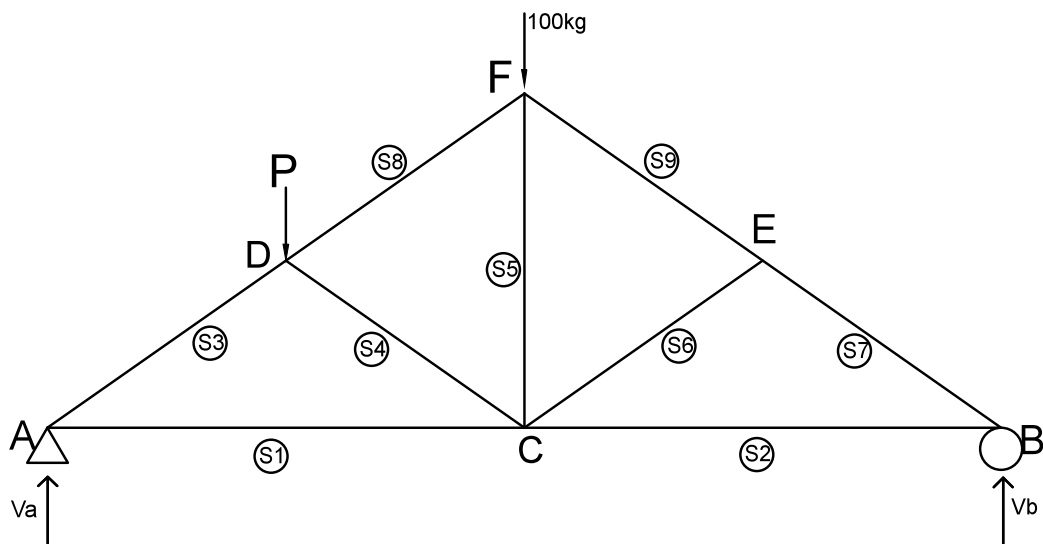
$$-S1 + S2 + S4 \cdot \cos 35^\circ - S6 \cdot \cos 35^\circ = 0$$

$$-(71,341 + 1,427P) + (71,341 + 1,427P) +$$

$$(0,871P)(0,819) - (0,871P)(0,819) = 0$$

$$0 = 0 \quad (\text{OK})$$

- Akibat beban luar vertical tidak simetris



$$\Sigma M_B = 0$$

$$V_A \cdot 300 - P \cdot 225 - P_T \cdot 150 = 0$$

$$V_A \cdot 300 - P \cdot 225 - 100 \cdot 150 = 0$$

$$300V_A = 15000 + 225P$$

$$V_A = 50 + 0,75P$$

$$\Sigma V = 0$$

$$V_A + V_B = P + P_T$$

$$(50 + 0,25P) + (50 + 0,75P) = 100 + P$$

$$100 + P = 100 + P \quad (\text{OK})$$

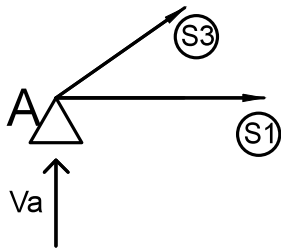
$$\Sigma M_B = 0$$

$$V_A \cdot 300 - P \cdot 225 - P_T \cdot 150 = 0$$

$$V_A \cdot 300 - P \cdot 225 - 100 \cdot 150 = 0$$

$$300V_A = 15000 + 225P$$

$$V_A = 50 + 0,75P$$

BUHUL A

$$\Sigma V = 0$$

$$V_A + S_3 \cdot \sin 35^\circ = 0$$

$$(50 + 0,75P) + S_3 \cdot 0,574 = 0$$

$$S_3 = \frac{-(50 + 0,75P)}{0,574}$$

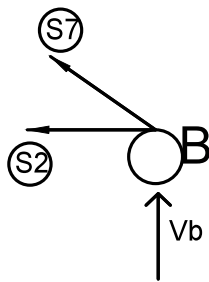
$$S_3 = -87,108 - 1,307P \text{ Kg (tekan)}$$

$$\Sigma H = 0$$

$$S_1 - S_3 \cdot \cos 35^\circ = 0$$

$$S_1 - (87,108 + 1,307P) \cdot 0,819 = 0$$

$$S_1 = 71,342 + 1,070P \text{ Kg (tarik)}$$

BUHUL B

$$\Sigma V = 0$$

$$V_B + S_7 \cdot \sin 35^\circ = 0$$

$$(50 + 0,25P) + S_7 \cdot 0,574 = 0$$

$$S_7 = \frac{-(50 + 0,25P)}{0,574}$$

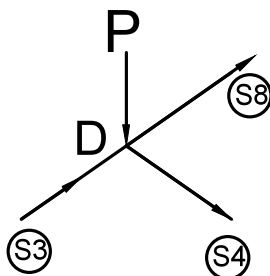
$$S_7 = -87,108 - 0,436P \text{ Kg (tekan)}$$

$$\Sigma H = 0$$

$$-S_2 + S_7 \cdot \cos 35^\circ = 0$$

$$-S_2 + (87,108 + 0,436P) = 0$$

$$S_2 = 71,342 + 0,357P \text{ Kg (tarik)}$$

BUHUL D

$$\Sigma V = 0$$

$$-P - S_4 \cdot \sin 35^\circ + S_8 \cdot \sin 35^\circ + S_3 \cdot \sin 35^\circ = 0$$

$$-P - 0,574S_4 + 0,574S_8 + (87,108 + 1,307P)(0,574) = 0$$

$$-0,574S_4 + 0,574S_8 = -50 + 0,25P \quad \dots (1)$$

$$\Sigma H = 0$$

$$S_8 \cdot \cos 35^\circ + S_3 \cdot \cos 35^\circ + S_4 \cdot \cos 35^\circ = 0$$

$$S_8 + S_4 = -S_3$$

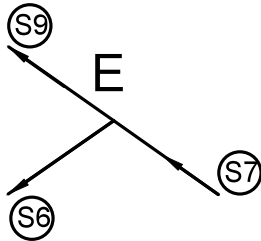
$$S_8 + S_4 = -87,108 - 1,307P \quad \dots (2)$$

Eliminasi (1) dan (2), didapat

$$S4 = -0,871P \text{ Kg (tekan)}$$

$$S8 = -87,108 - 0,436P \text{ Kg (tekan)}$$

BUHUL E



$$\Sigma V = 0$$

$$S9 \cdot \sin 35^\circ + S7 \cdot \sin 35^\circ - S6 \cdot \sin 35^\circ = 0$$

$$S9 - S6 = -S7$$

$$S9 - S6 = -87,108 - 0,436P \quad \dots (1)$$

$$\Sigma H = 0$$

$$-S9 \cdot \cos 35^\circ - S7 \cdot \cos 35^\circ - S6 \cdot \cos 35^\circ = 0$$

$$-S9 - S6 = S7$$

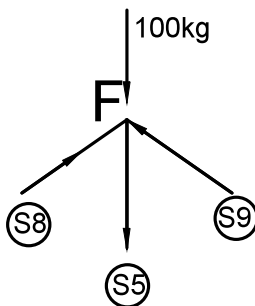
$$-S9 - S6 = 87,108 + 0,436P \quad \dots (2)$$

Eliminasi (1) dan (2), didapatkan

$$S6 = 0$$

$$S9 = -87,108 - 0,436P \text{ (tekan)}$$

BUHUL F



$$\Sigma V = 0$$

$$-P_T - S5 + S9 \cdot \sin 35^\circ + S8 \cdot \sin 35^\circ = 0$$

$$-100 - S5 + (87,108 + 0,436P)(0,574) + (87,108 + 0,436P)(0,574) = 0$$

$$-S5 = 100 - 50 - 0,25P - 50 - 0,25P$$

$$S5 = 0,5P \text{ (tarik)}$$

$$\Sigma H = 0$$

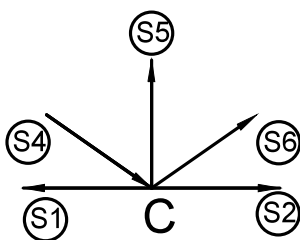
$$S8 \cdot \cos 35^\circ - S9 \cdot \cos 35^\circ = 0$$

$$S8 \cdot \cos 35^\circ = S9 \cdot \cos 35^\circ$$

$$(87,108 + 0,436P)(0,819) = (87,108 + 0,436P)(0,819)$$

$$71,341 + 0,357P = 71,341 + 0,357P \quad \text{(OK)}$$

BUHUL C



$$\Sigma V = 0$$

$$S5 + S6 \cdot \sin 35^\circ - S4 \cdot \sin 35^\circ = 0$$

$$0,5P - 0,871P(0,574) = 0$$

$$0,5P - 0,5P = 0$$

$$0 = 0 \quad \text{(OK)}$$

$$\Sigma H = 0$$

$$-S1 + S2 + S4.\cos 35^\circ + S6.\cos 35^\circ = 0$$

$$-71,342 - 1,070P + 71,342 + 0,357P + (0,871P).(0,819) = 0$$

$$-71,342 - 1,070P + 71,342 + 0,357P + 0,713P = 0$$

$$0 = 0 \quad (\text{OK})$$

3. Hitung jumlah beban total maksimum untuk batang tarik dan tekan.

Dibawah ini merupakan rekapitulasi gaya-gaya yang bekerja pada setiap batang

No. Batang	Gaya Batang (Kg)			Keterangan
	Akibat Berat Sendiri	Akibat Beban Luar		
		Vertikal Simetris	Vertikal Tidak Simetris	
1	61,812	1,427 P + 71,341	71,342 + 1,07 P	Tarik
2	61,812	1,427 P + 71,341	71,342 + 0,357 P	Tarik
3	-75,473	-1,742 P - 87,108	-87,108 - 1,3066 P	Tekan
4	-11,4769	-0,871 P	-0,871 P	Tekan
5	52,789	P	0,5 P	Tarik
6	-11,4769	-0,871 P	0	Tekan/Tekan/ -
7	-75,473	-1,742 P - 87,108	-87,108 - 0,436 P	Tekan
8	-63,9961	-0,871 P - 87,108	-87,108 - 0,436 P	Tekan
9	-63,9961	-0,871 P - 87,108	-87,108 - 0,436 P	Tekan

4. Hitung beban P_o yang ditahan batang sesuai kapasitas kuat tekan atau tarik bahan penyusun batang. Beton dan tulangan bambu pada batang tarik dan tekan.

Analisis Batang Beton Bertulang dengan Beban Axial Tekan Murni

$$P_o = 0,85.f'c.(A_g - A_{st \text{ Bambu}}) + (A_{st \text{ Bambu}}.f_{tk \text{ Bambu}})$$

$$= 0,85.10,8.(80^2 - 2.10^2) + (10^2.35,10)$$

$$= 56916 + 3510$$

$$= 60426 \text{ N} = 6042,6 \text{ Kg}$$

Analisis Batang Beton Bertulang dengan Beban Axial Tarik Murni

$$P_o = A_{st \text{ Bambu}}.f_{tr \text{ Bambu}}$$

$$= 10^2.149,67$$

$$= 14967 \text{ N}$$

$$= 1496,7 \text{ Kg}$$

5. Beban total maksimum batang tarik atau tekan terkecil menentukan beban P maks yang mampu ditahan

➤ Beban Vertikal Simetris

1. Tarik terbesar terjadi pada batang 1 atau 2 dengan nilai

$$S1_{TOTAL} = 61,812 + (1,427 P + 71,341)$$

Sehingga beban P total yang mampu ditahan oleh struktur adalah :

Gaya tarik maksimum pada batang 1

$$1496,7 = 61,812 + 1,427 P + 71,341$$

$$1,427 P = 1496,7 - 61,812 - 71,341$$

$$P_{max} = 955,5 \text{ Kg}$$

2. Tekan terbesar terjadi pada batang 3 atau 7 dengan nilai

$$S3_{TOTAL} = 75,473 + (1,742 P + 87,108)$$

Sehingga beban P total yang mampu ditahan oleh struktur adalah :

Gaya tekan maksimum pada batang 3

$$6042,6 = 75,473 + 1,742 P + 87,108$$

$$1,742 P = 6042,6 - 75,473 - 87,108$$

$$P_{max} = 3375,44 \text{ Kg}$$

P_{max} untuk beban vertikal simetris diambil yang terkecil yaitu **955,5Kg**

➤ Beban Vertikal Tidak Simetris

1. Tarik terbesar terjadi pada batang 1 dengan nilai

$$S1_{TOTAL} = 61,812 + (71,342 + 1,07 P)$$

Sehingga beban P total yang mampu ditahan oleh struktur adalah :

Gaya tarik maksimum pada batang 1

$$1496,7 = 61,812 + 71,342 + 1,07 P$$

$$1,070 P = 1496,7 - 61,812 - 71,342$$

$$P_{max} = 1274,34 \text{ Kg}$$

2. Tekan terbesar terjadi pada batang 3 dengan nilai

$$S3_{TOTAL} = 75,473 + (87,108 + 1,3066 P)$$

Sehingga beban P total yang mampu ditahan oleh struktur adalah :

Gaya tekan maksimum pada batang 3

$$6042,6 = 75,473 + 87,108 + 1,3066 P$$

$$1,3066 P = 6042,6 - 75,473 - 87,108$$

$$P_{max} = 4500,24 \text{ Kg}$$

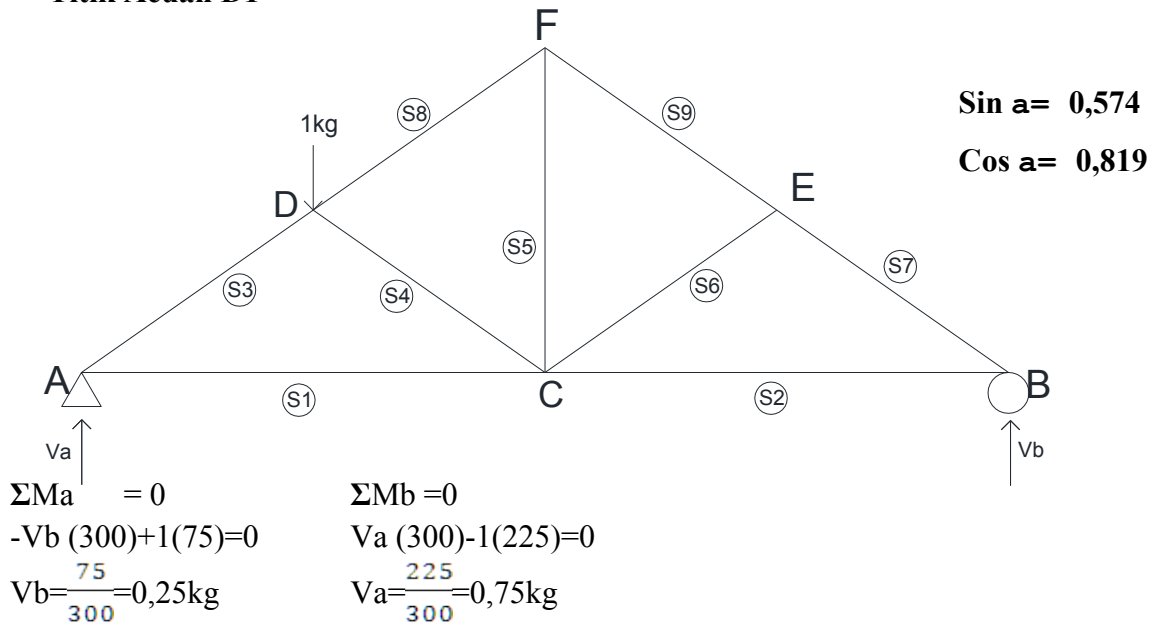
Pmax untuk beban Vertikal tidak simetris diambil yang terkecil yaitu **1274,34 Kg**

7. Perhitungan Deformasi Teoritis Kuda-Kuda

a. Beban 1kg pada Metode Unit Load

➤Vertikal Simetris

• Titik Acuan D1



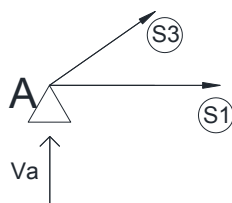
Kontrol

$$\Sigma V = 0$$

$$0,75 + 0,25 - 1 = 0$$

$$0 = 0$$

Titik A



$$\Sigma V = 0$$

$$V_a + S_3(\sin a) = 0$$

$$0,75 + 0,574(S_3) = 0$$

$$S_3 = -\frac{0,75}{0,574} = -1,307 \text{ kg (tekan)}$$

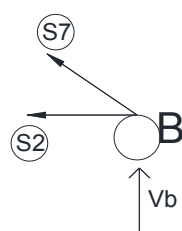
$$\Sigma H = 0$$

$$S_1 - S_3(\cos a) = 0$$

$$S_1 - 0,819(1,307) = 0$$

$$S_1 = 1,070 \text{ kg (tarik)}$$

Titik B



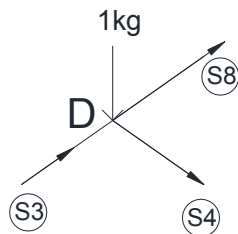
$$\Sigma V = 0$$

$$V_b + S_7(\sin a) = 0$$

$$0,25 + 0,574(S_7) = 0$$

$$S_7 = -0,436 \text{ kg (tekan)}$$

$$\Sigma H = 0$$

Titik D

$$-S_2 + S_7(\cos \alpha) = 0$$

$$-S_2 + 0,819(0,436) = 0$$

$$\mathbf{S_2 = 0,357 \text{ kg (tarik)}}$$

$$\Sigma V = 0$$

$$S_3(\sin \alpha) + S_8(\sin \alpha) - S_4(\sin \alpha) - 1 = 0$$

$$1,307(0,574) + S_8(0,574) - S_4(0,574) - 1 = 0$$

$$S_8(0,574) - S_4(0,574) = 0,25 \dots \text{persamaan 1}$$

$$\Sigma H = 0$$

$$S_3(\cos \alpha) + S_8(\cos \alpha) + S_4(\cos \alpha) = 0$$

$$S_3 + S_8 + S_4 = 0$$

$$S_4 + S_8 = -1,307 \dots \text{persamaan 2}$$

Jumlahkan pers.1 dan pers.2

$$S_8(0,574) - S_4(0,574) = 0,25$$

$$S_4(0,574) + S_8(0,574) = -0,75 \quad +$$

$$1,148 S_8 = -0,5$$

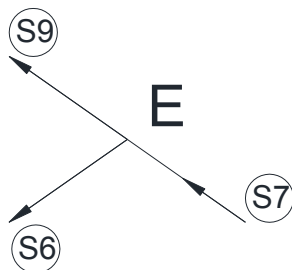
$$\mathbf{S_8 = -0,436 \text{ kg (tekan)}}$$

Substitusi

$$S_4 + S_8 = -1,307$$

$$S_4 + (-0,436) = -1,307$$

$$\mathbf{S_4 = -0,871 \text{ kg (tekan)}}$$

Titik E

$$\Sigma V = 0$$

$$S_7(\sin \alpha) + S_9(\sin \alpha) - S_6(\sin \alpha) = 0$$

$$S_7 + S_9 - S_6 = 0$$

$$S_9 - S_6 = -0,436 \dots \text{persamaan 1}$$

$$\Sigma H = 0$$

$$-S_9(\cos \alpha) - S_6(\cos \alpha) - S_7(\cos \alpha) = 0$$

$$S_9 + S_6 + S_7 = 0$$

$$S_9 + S_6 = -0,436 \dots \text{persamaan 2}$$

Jumlahkan pers.1 dengan pers.2

$$S_9 - S_6 = -0,436$$

$$S_9 + S_6 = -0,436 \quad +$$

$$2S_9 = -0,872$$

$$\mathbf{S_9 = -0,436 \text{ kg (tekan)}}$$

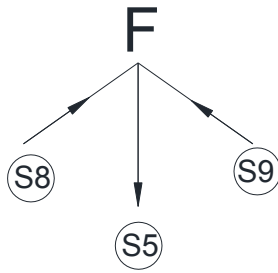
Substitusi

$$S_9 - S_6 = -0,436$$

$$-0,436 - S_6 = -0,436$$

$$\mathbf{S_6 = 0 \text{ (batang nol)}}$$

Titik F



$$\Sigma V=0$$

$$S8(\sin a) + S9(\sin a) - S5 = 0$$

$$0,436(0,574) + 0,436(0,574) = S5$$

$$S5 = 0,5 \text{ kg (tarik)}$$

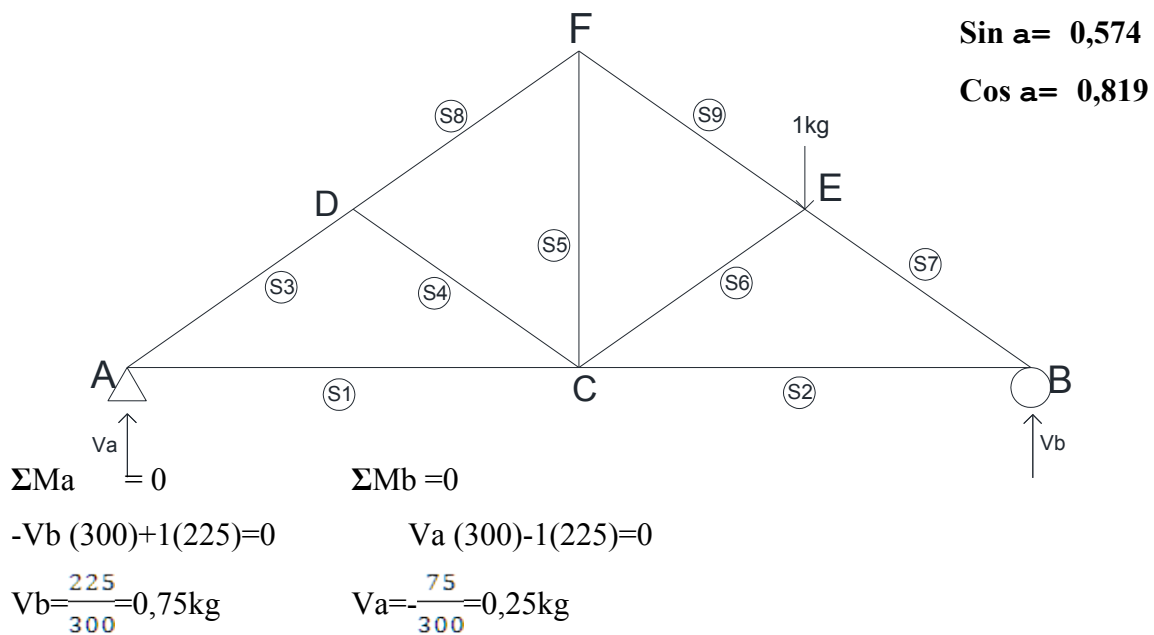
$$\Sigma H = 0$$

$$S8(\cos a) - S9(\cos a) = 0$$

$$0,436(0,819) - 0,436(0,819) = 0$$

$$0 = 0 \dots (\text{KONTROL})$$

• Titik Acuan D2



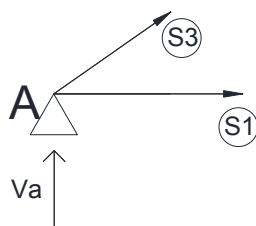
Kontrol

$$\Sigma V = 0$$

$$0,75 + 0,25 - 1 = 0$$

$$0 = 0$$

Titik A



$$\Sigma V = 0$$

$$V_a + S3(\sin a) = 0$$

$$0,25 + 0,574(S3) = 0$$

$$S3 = -\frac{0,25}{0,574} = -0,436 \text{ kg (tekan)}$$

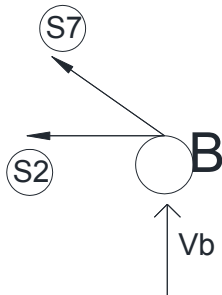
$$\Sigma H = 0$$

$$S1 - S3(\cos a) = 0$$

$$S1 - 0,819(0,436)=0$$

$$\mathbf{S1=0,357kg(tarik)}$$

Titik B



$$\Sigma V=0$$

$$Vb + S7(\sin a) = 0$$

$$0,75 + 0,574(S7)=0$$

$$\mathbf{S7 = -1,307kg (tekan)}$$

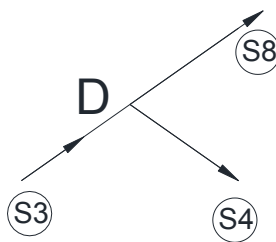
$$\Sigma H=0$$

$$-S2 + S7(\cos a) = 0$$

$$-S2 - 0,819(1,307)=0$$

$$\mathbf{S2=1,070kg(tarik)}$$

Titik D



$$\Sigma V= 0$$

$$S3(\sin a) + S8(\sin a) - S4(\sin a) = 0$$

$$S3 + S8 - S4 = 0$$

$$S4 - S8 = 0,436 \dots \text{persamaan 1}$$

$$\Sigma H= 0$$

$$S3(\cos a) + S8(\cos a) + S4(\cos a) = 0$$

$$S3 + S8 + S4 = 0$$

$$-S4 - S8 = 0,436 \dots \text{persamaan 2}$$

Jumlahkan pers.1 dan pers.2

$$S4 - S8 = 0,436$$

$$\underline{-S4 - S8 = 0,436 +}$$

$$-2S8 = 0,872$$

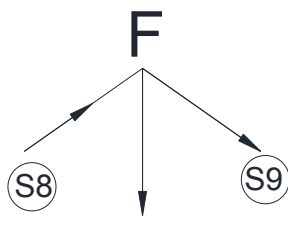
$$\mathbf{S8 = -0,436kg(tekan)}$$

Substitusi

$$S4 - (-0,436) = 0,436$$

$$\mathbf{S4 = 0kg(batang nol)}$$

Titik F



$$\Sigma H= 0$$

$$S8(\cos a) + S9(\cos a) = 0$$

$$0,436(0,819) + S9(0,819) = 0$$

$$S9 = -0,436 \text{ kg (tekan)}$$

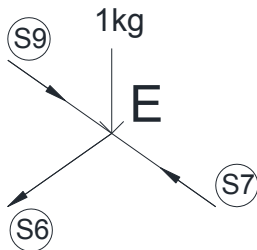
$$\Sigma V = 0$$

$$S8(\sin a) + S9(\sin a) - S5 = 0$$

$$0,436(0,574) + 0,436(0,574) = S5$$

$$S5 = 0,5 \text{ kg (tarik)}$$

Titik E



$$\Sigma V = 0$$

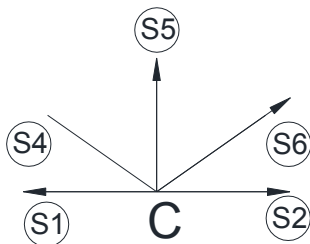
$$-S9(\sin a) + S7(\sin a) - S6(\sin a) - 1 = 0$$

$$-S9 + S7 - S6 - \frac{1}{\sin 35^\circ} = 0$$

$$-0,436 + 1,307 - S6 - \frac{1}{0,574} = 0$$

$$S6 = -0,871 \text{ kg (tekan)}$$

Titik C



$$\Sigma V = 0$$

$$S5 - S6(\sin a) = 0$$

$$0,5 - 0,871(0,574) = 0$$

$$0,5 - 0,5 = 0 \dots (\text{KONTROL})$$

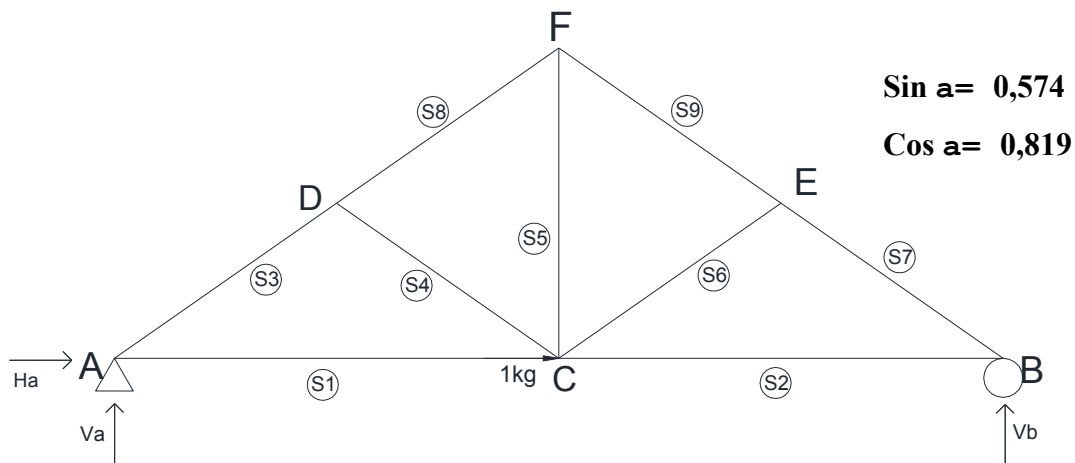
$$\Sigma H = 0$$

$$-S1 + S2 - S6(\cos a) = 0$$

$$-0,357 + 1070 - 0,871(0,819) = 0$$

$$0 = 0 \dots (\text{KONTROL})$$

• Titik Acuan D3



$$\sin a = 0,574$$

$$\cos a = 0,819$$

$$\Sigma M_a = 0$$

$$-V_b(300) = 0$$

$$V_b = 0 \text{ kg}$$

$$\Sigma H = 0$$

$$H_a + 1 = 0$$

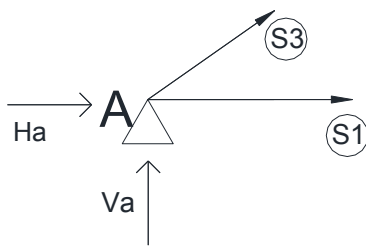
$$\Sigma M_b = 0$$

$$V_a(300) = 0$$

$$V_a = 0 \text{ kg}$$

$H_a = -1\text{kg}$

Titik A



$$\Sigma V = 0$$

$$V_a + S_3(\sin a) = 0$$

$$0 + S_3(\sin a) = 0$$

$$S_3 = 0$$

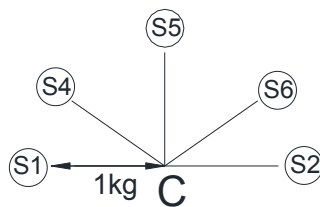
$$\Sigma H = 0$$

$$-H_a + S_1 = 0$$

$$-1 + S_1 = 0$$

$$S_1 = 1\text{kg}(\text{tarik})$$

Titik C



$$\Sigma H = 0$$

$$-S_1 + 1 = 0$$

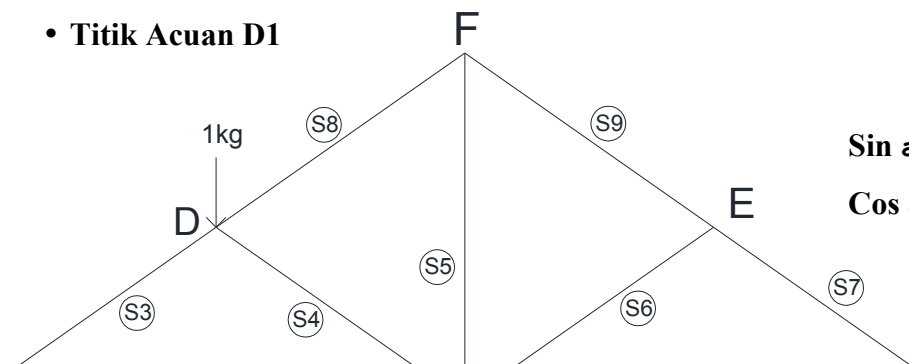
$$-1 + 1 = 0$$

$$0 = 0 \dots (\text{KONTROL})$$

No. Batang	D1		D2		D3	
	Gaya Batang (kg)	Keterangan	Gaya Batang (kg)	Keterangan	Gaya Batang (kg)	Keterangan
S1	1,07	tarik	0,357	tarik	1	tarik
S2	0,357	tarik	1,07	tarik	0	-
S3	-1,307	tekan	-0,436	tekan	0	-
S4	-0,871	tekan	0	-	0	-
S5	0,5	tarik	0,5	tarik	0	-
S6	0	-	-0,871	tekan	0	-
S7	-0,436	tekan	-1,307	tekan	0	-
S8	-0,436	tekan	-0,436	tekan	0	-
S9	-0,436	tekan	-0,436	tekan	0	-

➤ Vertikal Tidak Simetris

• Titik Acuan D1



$$\sin a = 0,574$$

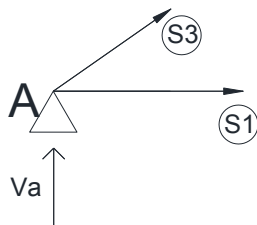
$$\cos a = 0,819$$

$$\begin{aligned}\Sigma M_a &= 0 \\ -V_b(300) + 1(75) &= 0 \\ V_b &= \frac{75}{300} = 0,25 \text{ kg}\end{aligned}$$

Kontrol

$$\begin{aligned}\Sigma V &= 0 \\ 0,75 + 0,25 - 1 &= 0 \\ 0 &= 0\end{aligned}$$

Titik A

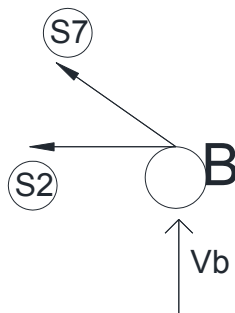


$$\begin{aligned}\Sigma M_b &= 0 \\ V_a(300) + 1(225) &= 0 \\ V_a &= \frac{225}{300} = 0,75 \text{ kg}\end{aligned}$$

$$\begin{aligned}\Sigma V &= 0 \\ V_a + S3(\sin \alpha) &= 0 \\ 0,75 + 0,574(S3) &= 0 \\ S3 &= -\frac{0,75}{0,574} = -1,307 \text{ kg (tekan)}\end{aligned}$$

$$\begin{aligned}\Sigma H &= 0 \\ S1 - S3(\cos \alpha) &= 0 \\ S1 - 0,819(1,307) &= 0 \\ S1 &= 1,070 \text{ kg (tarik)}\end{aligned}$$

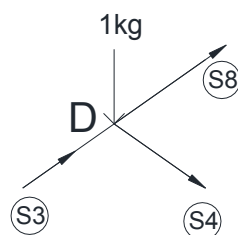
Titik B



$$\begin{aligned}\Sigma V &= 0 \\ V_b + S7(\sin \alpha) &= 0 \\ 0,25 + 0,574(S7) &= 0 \\ S7 &= -0,436 \text{ kg (tekan)}\end{aligned}$$

$$\begin{aligned}\Sigma H &= 0 \\ -S2 + S7(\cos \alpha) &= 0 \\ -S2 - 0,819(0,436) &= 0 \\ S2 &= 0,357 \text{ kg (tarik)}\end{aligned}$$

Titik D



$$\begin{aligned}\Sigma V &= 0 \\ S3(\sin \alpha) + S8(\sin \alpha) - S4(\sin \alpha) - 1 &= 0 \\ 1,307(0,574) + S8(0,574) - S4(0,574) &= 0 \\ S8(0,574) - S4(0,574) &= 0,25 \dots \text{persamaan 1} \\ \Sigma H &= 0 \\ S3(\cos \alpha) + S8(\cos \alpha) + S4(\cos \alpha) &= 0 \\ S3 + S8 + S4 &= 0 \\ S4 + S8 &= -1,307 \dots \text{persamaan 2}\end{aligned}$$

Jumlahkan pers.1 dan pers.2

$$S8(0,574) - S4(0,574) = 0,25$$

$$\frac{S4(0,574) + S8(0,574)}{1,148S8} = \frac{-0,75}{-0,5}$$

$$\mathbf{S8 = -0,436kg(tekan)}$$

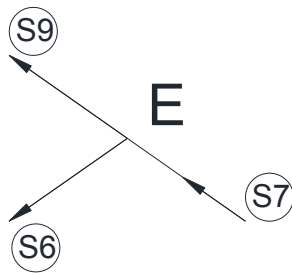
Subtitusi

$$S4 + S8 = -1,307$$

$$S4 + (-0,436) = -1,307$$

$$\mathbf{S4 = -0,871kg(tekan)}$$

Titik E



$$\Sigma V = 0$$

$$S7(\sin \alpha) + S9(\sin \alpha) - S6(\sin \alpha) = 0$$

$$S7 + S9 - S6 = 0$$

$$S9 - S6 = -0,436 \dots \text{persamaan 1}$$

$$\Sigma H = 0$$

$$-S9(\cos \alpha) - S6(\cos \alpha) - S7(\cos \alpha) = 0$$

$$S9 + S6 + S7 = 0$$

$$S9 + S6 = -0,436 \dots \text{persamaan 2}$$

Jumlahkan pers.1 dengan pers.2

$$S9 - S6 = -0,436$$

$$\frac{S9 + S6 = -0,436}{2S9} = \frac{-0,872}{2}$$

$$2S9 = -0,872$$

$$\mathbf{S9 = -0,436kg(tekan)}$$

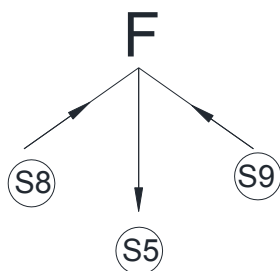
Subtitusi

$$S9 - S6 = -0,436$$

$$-0,436 - S6 = -0,436$$

$$\mathbf{S6 = 0 \text{ (batang nol)}}$$

Titik F



$$\Sigma V = 0$$

$$S8(\sin \alpha) + S9(\sin \alpha) - S5 = 0$$

$$0,436(0,574) + 0,436(0,574) = S5$$

$$\mathbf{S5 = 0,5kg \text{ (tarik)}}$$

$$\Sigma H = 0$$

$$S8(\cos \alpha) - S9(\cos \alpha) = 0$$

$$0,436(0,819) - 0,436(0,819) = 0$$

$$\mathbf{0 = 0 \dots (KONTROL)}$$



• Titik Acuan D2

$$\sin a = 0,574$$

$$\cos a = 0,819$$

$$\Sigma M_a = 0$$

$$-V_b(300) + 1(225) = 0$$

$$V_b = \frac{225}{300} = 0,75 \text{ kg}$$

$$\Sigma M_b = 0$$

$$V_a(300) + 1(225) = 0$$

$$V_a = \frac{75}{300} = 0,25 \text{ kg}$$

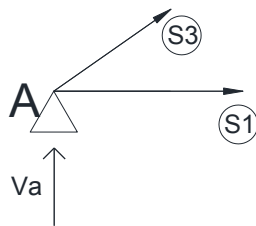
Kontrol

$$\Sigma V = 0$$

$$0,75 + 0,25 - 1 = 0$$

$$0 = 0$$

Titik A



$$\Sigma V = 0$$

$$V_a + S3(\sin a) = 0$$

$$0,25 + 0,574(S3) = 0$$

$$S3 = -\frac{0,25}{0,574} = -0,436 \text{ kg (tekan)}$$

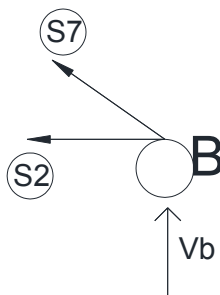
$$\Sigma H = 0$$

$$S1 - S3(\cos a) = 0$$

$$S1 - 0,819(0,436) = 0$$

$$S1 = 0,357 \text{ (tarik)}$$

Titik B



$$\Sigma V = 0$$

$$V_b + S7(\sin a) = 0$$

$$0,75 + 0,574(S7) = 0$$

$$S7 = -1,307 \text{ kg (tekan)}$$

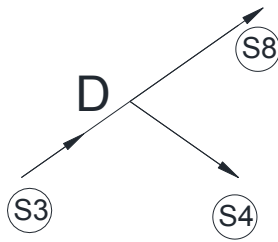
$$\Sigma H = 0$$

$$-S2 + S7(\cos a) = 0$$

$$-S2 - 0,819(1,307) = 0$$

$$S2 = 1,070 \text{ (tarik)}$$

Titik D



$$\Sigma V = 0$$

$$S3(\sin \alpha) + S8(\sin \alpha) - S4(\sin \alpha) = 0$$

$$S3 + S8 - S4 = 0$$

$$S4 - S8 = 0,436 \dots \text{persamaan 1}$$

$$\Sigma H = 0$$

$$S3(\cos \alpha) + S8(\cos \alpha) + S4(\cos \alpha) = 0$$

$$S3 + S8 + S4 = 0$$

$$-S4 - S8 = 0,436 \dots \text{persamaan 2}$$

Jumlahkan pers.1 dan pers.2

$$S4 - S8 = 0,436$$

$$-S4 - S8 = 0,436 +$$

$$-2S8 = 0,872$$

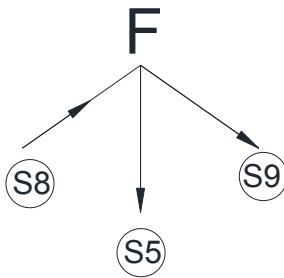
$$S8 = -0,436(\text{tekan})$$

Substitusi

$$S4 - (-0,436) = 0,436$$

$$S4 = 0$$

Titik F



$$\Sigma H = 0$$

$$S8(\cos \alpha) + S9(\cos \alpha) = 0$$

$$0,436(0,819) + S9(0,819) = 0$$

$$S9 = -0,436(\text{tekan})$$

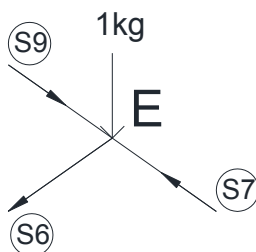
$$\Sigma V = 0$$

$$S8(\sin \alpha) + S9(\sin \alpha) - S5 = 0$$

$$0,436(0,574) + 0,436(0,574) = S5$$

$$S5 = 0,5\text{kg}(\text{tarik})$$

Titik E



$$\Sigma V = 0$$

$$-S9(\sin \alpha) + S7(\sin \alpha) - S6(\sin \alpha) - 1 = 0$$

$$-S9 + S7 - S6 - \frac{1}{\sin 35^\circ} = 0$$

$$-0,436 + 1,307 - S6 - \frac{1}{0,574} = 0$$

$$S6 = -0,871\text{kg}(\text{tekan})$$

Titik C

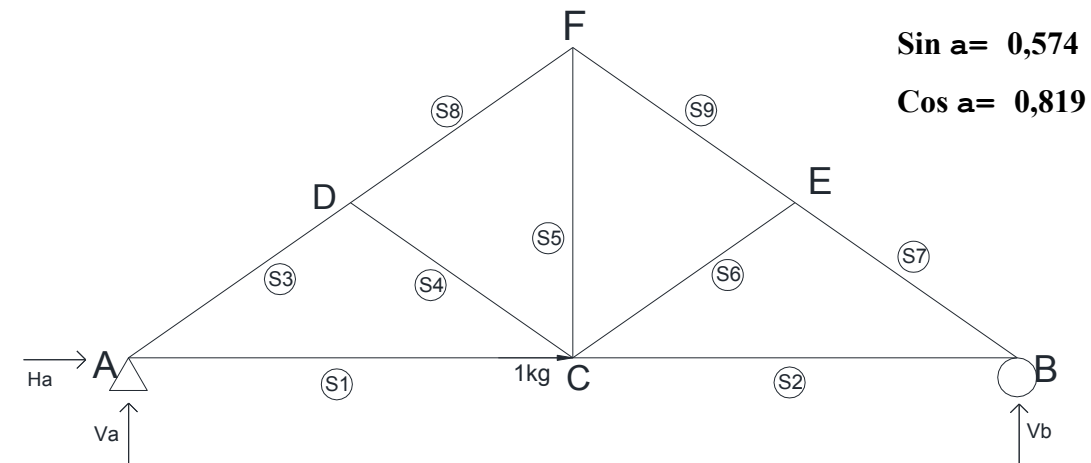


$$\Sigma V = 0$$

$$S5 - S6(\sin \alpha) = 0$$

$$\begin{aligned}
 0,5 - 0,871(0,574) &= 0 \\
 0,5 - 0,5 &= 0 \dots (\text{KONTROL}) \\
 \Sigma H &= 0 \\
 -S1 + S2 - S6(\cos a) &= 0 \\
 -0,357 + 1070 - 0,871(0,819) &= 0 \\
 0 &= 0 \dots (\text{KONTROL})
 \end{aligned}$$

• **Titik Acuan D3**



$$\begin{aligned}
 \Sigma M_a &= 0 & \Sigma M_b &= 0 \\
 -V_b(300) &= 0 & V_a(300) &= 0 \\
 V_b &= 0 \text{ kg} & V_a &= 0 \text{ kg} \\
 \Sigma H &= 0 \\
 H_a + 1 &= 0 \\
 H_a &= -1 \text{ kg}
 \end{aligned}$$

Titik A

$$\begin{aligned}
 \Sigma V &= 0 \\
 V_a + S3(\sin a) &= 0 \\
 0 + S3(\sin a) &= 0 \\
 S3 &= 0 \\
 \Sigma H &= 0 \\
 -H_a + S1 &= 0 \\
 -1 + S1 &= 0 \\
 \mathbf{S1} &= \mathbf{1 \text{ kg (tarik)}}
 \end{aligned}$$

Titik C

$$\begin{aligned}
 \Sigma H &= 0 \\
 -S1 + 1 &= 0 \\
 -1 + 1 &= 0
 \end{aligned}$$

0=0...(KONTROL)

No.Batang	D1		D2		D3	
	Gaya Batang (kg)	Keterangan	Gaya Batang (kg)	Keterangan	Gaya Batang (kg)	Keterangan
S1	1,07	tarik	0,357	tarik	1	tarik
S2	0,357	tarik	1,07	tarik	0	-
S3	-1,307	tekan	-0,436	tekan	0	-
S4	-0,871	tekan	0	-	0	-
S5	0,5	tarik	0,5	tarik	0	-
S6	0	-	-0,871	tekan	0	-
S7	-0,436	tekan	-1,307	tekan	0	-
S8	-0,436	tekan	-0,436	tekan	0	-
S9	-0,436	tekan	-0,436	tekan	0	-

b. Tabel perhitungan deformasi teoritis (elastis saat P=50kg)

➤Vertikal Simetris

• D1

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
No	S (kg)		L	A . E	$\Delta L = [(2)+(3)] \cdot (4) / (5)$	Vertikal	
Batang	Berat Sendiri	Beban Luar	mm	Kg	mm	S'v (Kg)	$\Delta d1 = (6) \cdot (7) \text{ (mm)}$
1	61,812	142,691	1500	7901960,179	0,0388	1,07	0,0415
2	61,812	142,691	1500	7901960,179	0,0388	0,357	0,0139
3	-75,473	-174,208	822,5	7901960,179	-0,0260	-1,307	0,0340
4	-11,48	-43,55	637,4	7901960,179	-0,0044	-0,871	0,0039
5	52,79	50	1009,3	15803920,36	0,0066	0,5	0,0033

6	-11,48	-43,55	637,4	7901960,179	-0,0044	0	0,0000
7	-75,473	-174,208	822,5	7901960,179	-0,0260	-0,436	0,0113
8	-63,99	-130,658	633,3	7901960,179	-0,0156	-0,436	0,0068
9	-63,99	-130,658	633,3	7901960,179	-0,0156	-0,436	0,0068
TOTAL							0,1214

• D2

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
No	S (kg)		L	A . E	$\Delta L = [(2)+(3)] \cdot (4) / (5)$	Vertikal	
Batang	Berat Sendiri	Beban Luar	mm	Kg	mm	S'v (Kg)	$\Delta d2 = (6) \cdot (7) \text{ (mm)}$
1	61,812	142,691	1500	7901960,179	0,0388	0,357	0,0139
2	61,812	142,691	1500	7901960,179	0,0388	1,07	0,0415
3	-75,473	-174,208	822,5	7901960,179	-0,0260	-0,436	0,0113
4	-11,48	-43,55	637,4	7901960,179	-0,0044	0	0,0000
5	52,79	50	1009,3	15803920,36	0,0066	0,5	0,0033
6	-11,48	-43,55	637,4	7901960,179	-0,0044	-0,871	0,0039
7	-75,473	-174,208	822,5	7901960,179	-0,0260	-1,307	0,0340
8	-63,99	-130,658	633,3	7901960,179	-0,0156	-0,436	0,0068
9	-63,99	-130,658	633,3	7901960,179	-0,0156	-0,436	0,0068
TOTAL							0,1214

• D3

(1)	(2)	(3)	(4)	(5)	(6)	(9)	(10)
No	S (kg)		L	A . E	$\Delta L = [(2)+(3)] \cdot (4) / (5)$	Horizontal	
Batang	Berat Sendiri	Beban Luar	mm	Kg	mm	S'h (Kg)	$\Delta d3 = (6) \cdot (9) \text{ (mm)}$
1	61,812	142,691	1500	7901960,179	0,0388	1	0,0388
2	61,812	142,691	1500	7901960,179	0,0388	0	0
3	-75,473	-174,208	822,5	7901960,179	-0,0260	0	0
4	-11,48	-43,55	637,4	7901960,179	-0,0044	0	0
5	52,79	50	1009,3	15803920,36	0,0066	0	0
6	-11,48	-43,55	637,4	7901960,179	-0,0044	0	0

7	-75,473	-174,208	822,5	7901960,179	-0,0260	0	0
8	-63,99	-130,658	633,3	7901960,179	-0,0156	0	0
9	-63,99	-130,658	633,3	7901960,179	-0,0156	0	0
						TOTAL	0,0388

➤ Vertikal Tidak Simetris

• D1

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
No	S (kg)		L	A . E	$\Delta L = [(2)+(3)] \cdot (4) / (5)$	Vertikal	
Batang	Berat Sendiri	Beban Luar	mm	Kg	mm	S'v (Kg)	$\Delta d1 = (6) \cdot (7) \text{ (mm)}$
1	61,812	124,842	1500	7901960,179	0,0354	1,07	0,0379
2	61,812	124,842	1500	7901960,179	0,0354	0,357	0,0126
3	-75,473	-152,458	822,5	7901960,179	-0,0237	-1,307	0,0310
4	-11,48	-43,550	637,4	7901960,179	-0,0044	-0,871	0,0039
5	52,79	25,000	1009,3	15803920,36	0,0050	0,5	0,0025
6	-11,48	0,000	637,4	7901960,179	-0,0009	0	0,0000
7	-75,473	-152,458	822,5	7901960,179	-0,0237	-0,436	0,0103
8	-63,99	-108,908	633,3	7901960,179	-0,0139	-0,436	0,0060
9	-63,99	-108,908	633,3	7901960,179	-0,0139	-0,436	0,0060
						TOTAL	0,1103

• D2

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
No	S (kg)		L	A . E	$\Delta L = [(2)+(3)] \cdot (4) / (5)$	Vertikal	
Batang	Berat Sendiri	Beban Luar	mm	Kg	mm	S'v (Kg)	$\Delta d2 = (6) \cdot (7) \text{ (mm)}$
1	61,812	124,842	1500	7901960,179	0,0354	0,357	0,0126
2	61,812	124,842	1500	7901960,179	0,0354	1,07	0,0379
3	-75,473	-152,458	822,5	7901960,179	-0,0237	-0,436	0,0103
4	-11,48	-43,550	637,4	7901960,179	-0,0044	0	0,0000
5	52,79	25,000	1009,3	15803920,36	0,0050	0,5	0,0025
6	-11,48	0,000	637,4	7901960,179	-0,0009	-0,871	0,0008

7	-75,473	-152,458	822,5	7901960,179	-0,0237	-1,307	0,0310
8	-63,99	-108,908	633,3	7901960,179	-0,0139	-0,436	0,0060
9	-63,99	-108,908	633,3	7901960,179	-0,0139	-0,436	0,0060
						TOTAL	0,1073

• D3

(1)	(2)	(3)	(4)	(5)	(6)	(9)	(10)
No	S (kg)		L	A . E	$\Delta L = [(2)+(3)] \cdot (4) / (5)$	Horizontal	
Batang	Berat Sendiri	Beban Luar	mm	Kg	mm	S'h (Kg)	$\Delta d3 = (6) \cdot (9) \text{ (mm)}$
1	61,812	124,842	1500	7901960,179	0,0354	1	0,0354
2	61,812	124,842	1500	7901960,179	0,0354	0	0
3	-75,473	-152,458	822,5	7901960,179	-0,0237	0	0
4	-11,48	-43,550	637,4	7901960,179	-0,0044	0	0
5	52,79	25,000	1009,3	15803920,36	0,0050	0	0
6	-11,48	0,000	637,4	7901960,179	-0,0009	0	0
7	-75,473	-152,458	822,5	7901960,179	-0,0237	0	0
8	-63,99	-108,908	633,3	7901960,179	-0,0139	0	0
9	-63,99	-108,908	633,3	7901960,179	-0,0139	0	0
						TOTAL	0,0354

Rekapitulasi Deformasi Teoritis Saat P elastis (P=50kg)

Benda Uji	P Elastis Tinjauan (kg)	Deformasi Teoritis Δ Elastis (mm)		
		D1	D2	D3
Vertikal Simetris	50	0,12145	0,12145	0,03882
Vertikal Tidak Simetris	50	0,11035	0,10729	0,03543