

### Lampiran 1. Komposisi Campuran Beton Aspal pada Aspal Pen 60 ( Benda Uji 1 )

Ukuran		Berat Jenis (G)			Komposisi Campuran Terhadap Berat Total Campuran (P)						
		Apparent	Bulk		1	2	3	4	5	6	7
½ inch	G1	2,597	2,755	P1	9,6	9,55	9,50	9,45	9,40	9,35	9,30
3/8 inch	G2	2,596	2,761	P2	9,6	9,55	9,50	9,45	9,40	9,35	9,30
No. 4	G3	2,595	2,796	P3	19,2	19,10	19,00	18,90	18,80	18,70	18,60
No. 8	G4	2,206	2,344	P4	16,8	16,71	16,63	16,54	16,45	16,36	16,28
No. 30	G5	2,391	2,542	P5	18,24	18,15	18,05	17,96	17,86	17,77	17,67
No. 50	G6	2,243	2,389	P6	5,28	5,25	5,23	5,20	5,17	5,14	5,12
No. 100	G7	2,402	2,545	P7	5,76	5,73	5,70	5,67	5,64	5,61	5,58
No. 200	G8	2,351	2,497	P8	4,8	4,78	4,75	4,73	4,70	4,68	4,65
Pan	G9	2,68	2,68	P9	6,72	6,69	6,65	6,62	6,58	6,55	6,51
Total Agregat	Gs			Ps	96	95,5	95	94,5	94	93,5	93
Aspal	Gb	1,03	1,03	Pb	4	4,5	5	5,5	6	6,5	7
1 Berat Jenis Bulk (Gsb), Agregat Total					2,5376	2,5376	2,5376	2,5376	2,5376	2,5376	2,5376
2 Berat Jenis Apparent (Gsa), Agregat Total					2,6434	2,6434	2,6434	2,6434	2,6434	2,6434	2,6434
3 Berat Jenis Effectif (Gse), Agregat Total					2,5905	2,5905	2,5905	2,5905	2,5905	2,5905	2,5905
4 Berat Jenis Maksimum (Gmm), Campuran					2,4285	2,4096	2,3911	2,3728	2,3548	2,3371	2,3196
5 Kepadatan (Gmb)					2,136	2,231	2,231	2,182	2,273	2,241	2,267
6 Kadar Aspal Terserap (Pba), (%)					0,8284	0,8284	0,8284	0,8284	0,8284	0,8284	0,8284
7 Kadar Aspal Effectif (Pbe), (%)					3,2048	3,7089	4,2131	4,7172	5,2213	5,7255	6,2296
8 Rongga dalam Agregat (%)					19,196	16,021	16,471	18,736	15,795	17,435	16,9
9 Rongga dalam Campuran (%)					12,048	7,393	6,687	8,034	3,467	4,119	2,2471

**Lampiran 2. Komposisi Campuran Beton Aspal pada Aspal Pen 60 ( Benda Uji 2 )**

Ukuran		Berat Jenis (G)			Komposisi Campuran Terhadap Berat Total Campuran (P)						
		Apparent	Bulk		1	2	3	4	5	6	7
½ inch	G1	2,597	2,755	P1	9,6	9,55	9,50	9,45	9,40	9,35	9,30
3/8 inch	G2	2,596	2,761	P2	9,6	9,55	9,50	9,45	9,40	9,35	9,30
No. 4	G3	2,595	2,796	P3	19,2	19,10	19,00	18,90	18,80	18,70	18,60
No. 8	G4	2,206	2,344	P4	16,8	16,71	16,63	16,54	16,45	16,36	16,28
No. 30	G5	2,391	2,542	P5	18,24	18,15	18,05	17,96	17,86	17,77	17,67
No. 50	G6	2,243	2,389	P6	5,28	5,25	5,23	5,20	5,17	5,14	5,12
No. 100	G7	2,402	2,545	P7	5,76	5,73	5,70	5,67	5,64	5,61	5,58
No. 200	G8	2,351	2,497	P8	4,8	4,78	4,75	4,73	4,70	4,68	4,65
Pan	G9	2,68	2,68	P9	6,72	6,69	6,65	6,62	6,58	6,55	6,51
Total Agregat	Gs			Ps	96	95,5	95	94,5	94	93,5	93
Aspal	Gb	1,03	1,03	Pb	4	4,5	5	5,5	6	6,5	7
1 Berat Jenis Bulk (Gsb), Agregat Total					2,5376	2,5376	2,5376	2,5376	2,5376	2,5376	2,5376
2 Berat Jenis Apparent (Gsa), Agregat Total					2,6434	2,6434	2,6434	2,6434	2,6434	2,6434	2,6434
3 Berat Jenis Effectif (Gse), Agregat Total					2,5905	2,5905	2,5905	2,5905	2,5905	2,5905	2,5905
4 Berat Jenis Maksimum (Gmm), Campuran					2,4285	2,4096	2,3911	2,3728	2,3548	2,3371	2,3196
5 Kepadatan (Gmb)					2,211	2,184	2,166	2,213	2,245	2,236	2,255
6 Kadar Aspal Terserap (Pba), (%)					0,8284	0,8284	0,8284	0,8284	0,8284	0,8284	0,8284
7 Kadar Aspal Effektif (Pbe), (%)					3,2048	3,7089	4,2131	4,7172	5,2213	5,7255	6,2296
8 Rongga dalam Agregat (%)					16,372	17,819	18,9	17,584	16,821	17,622	17,393
9 Rongga dalam Campuran (%)					8,974	9,375	9,401	6,730	4,642	4,337	2,764

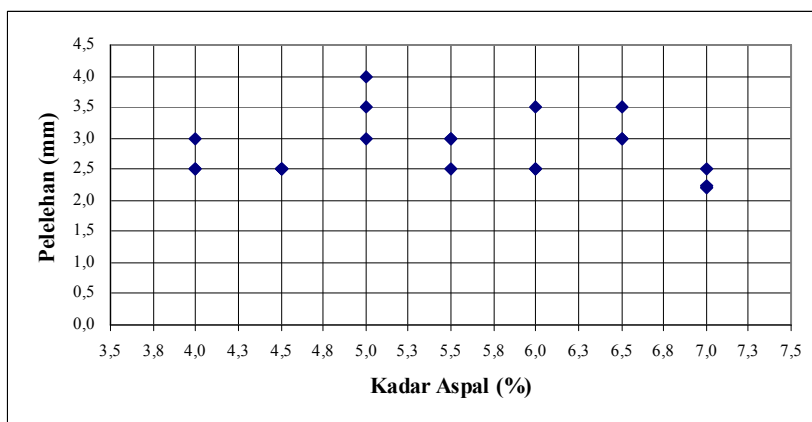
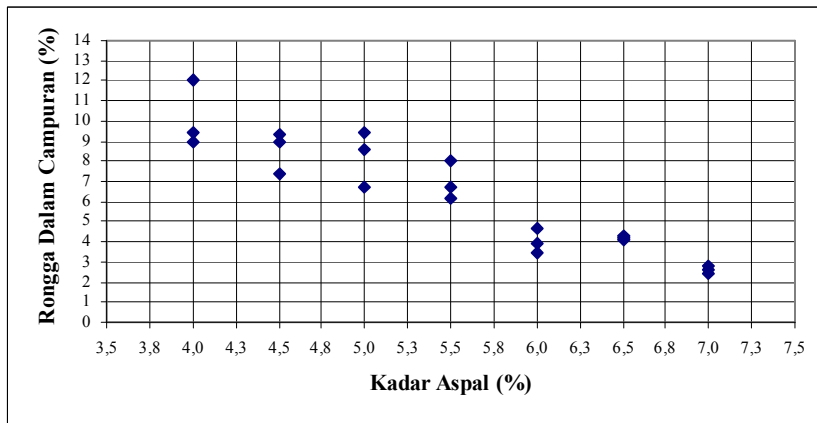
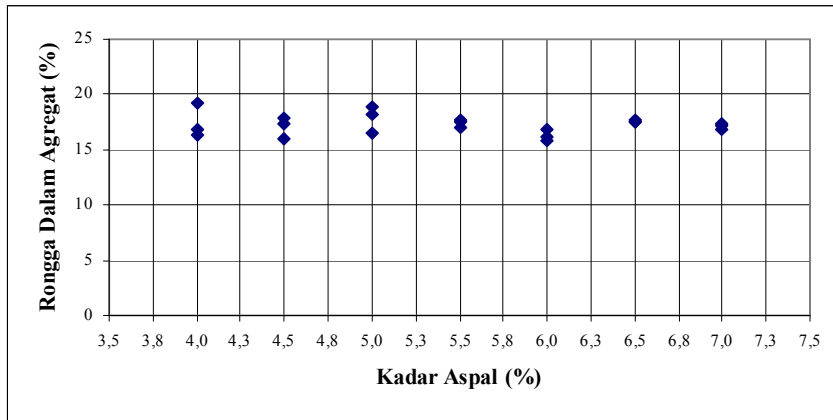
**Lampiran 3. Komposisi Campuran Beton Aspal pada Aspal Pen 60 ( Benda Uji 3 )**

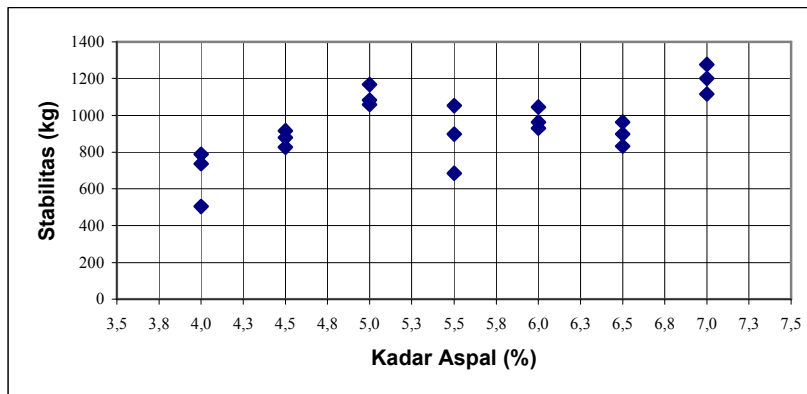
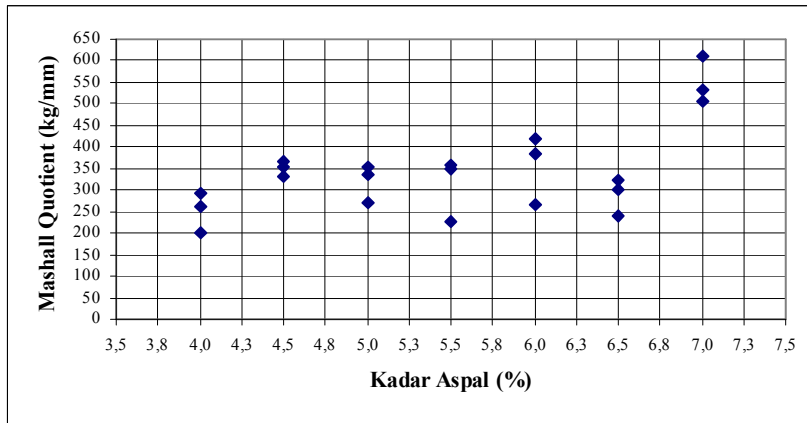
Ukuran		Berat Jenis (G)			Komposisi Campuran Terhadap Berat Total Campuran (P)						
		Apparent	Bulk		1	2	3	4	5	6	7
½ inch	G1	2,597	2,755	P1	9,6	9,55	9,50	9,45	9,40	9,35	9,30
3/8 inch	G2	2,596	2,761	P2	9,6	9,55	9,50	9,45	9,40	9,35	9,30
No. 4	G3	2,595	2,796	P3	19,2	19,10	19,00	18,90	18,80	18,70	18,60
No. 8	G4	2,206	2,344	P4	16,8	16,71	16,63	16,54	16,45	16,36	16,28
No. 30	G5	2,391	2,542	P5	18,24	18,15	18,05	17,96	17,86	17,77	17,67
No. 50	G6	2,243	2,389	P6	5,28	5,25	5,23	5,20	5,17	5,14	5,12
No. 100	G7	2,402	2,545	P7	5,76	5,73	5,70	5,67	5,64	5,61	5,58
No. 200	G8	2,351	2,497	P8	4,8	4,78	4,75	4,73	4,70	4,68	4,65
Pan	G9	2,68	2,68	P9	6,72	6,69	6,65	6,62	6,58	6,55	6,51
Total Agregat	Gs			Ps	96	95,5	95	94,5	94	93,5	93
Aspal	Gb	1,03	1,03	Pb	4	4,5	5	5,5	6	6,5	7
1 Berat Jenis Bulk (Gsb), Agregat Total					2,5376	2,5376	2,5376	2,5376	2,5376	2,5376	2,5376
2 Berat Jenis Apparent (Gsa), Agregat Total					2,6434	2,6434	2,6434	2,6434	2,6434	2,6434	2,6434
3 Berat Jenis Effectif (Gse), Agregat Total					2,5905	2,5905	2,5905	2,5905	2,5905	2,5905	2,5905
4 Berat Jenis Maksimum (Gmm), Campuran					2,4285	2,4096	2,3911	2,3728	2,3548	2,3371	2,3196
5 Kepadatan (Gmb)					2,199	2,194	2,187	2,227	2,262	2,238	2,259
6 Kadar Aspal Terserap (Pba), (%)					0,8284	0,8284	0,8284	0,8284	0,8284	0,8284	0,8284
7 Kadar Aspal Effektif (Pbe), (%)					3,2048	3,7089	4,2131	4,7172	5,2213	5,7255	6,2296
8 Rongga dalam Agregat (%)					16,793	17,425	18,142	17,052	16,219	17,527	17,224
9 Rongga dalam Campuran (%)					9,472	8,941	8,554	6,128	3,952	4,227	2,629

**Lampiran 4. Hasil Percobaan Marshall untuk Memperoleh Kadar Aspal Optimum Menggunakan Aspal Pen 60**

Kadar Aspal (%)	No. Benda Uji	Berat Benda Uji			d (cm)	Angka Korelasi	t (cm)	Bulk Volume (ml)	Kepadatan (gr/ml)	Rongga dalam Campuran (%)	Rongga dalam Agregat (%)	Stabilitas Marshall yang sudah dikoreksi (kg)	Pelelehan (mm)	Marshall Quotient (kg/mm)
		Kering (gr)	Kering Permukaan Jenuh (gr)	Dalam Air (gr)										
4 %	1	1089,1	1123,9	614	6,517	0,928	10,128	509,90	2,136	12,048	19,196	787,754	3	262,585
	2	1105,5	1140,1	640	6,565	0,916	10,178	500,10	2,211	8,974	16,372	736698	2,5	294,439
	3	1100,6	1144,4	644	6,595	0,909	10,188	500,40	2,199	9,432	16,793	503,646	2,5	201,458
Rata-rata									2,182	10,152	17,454	675,833	2,667	252,827
4,5 %	1	1113,5	1145	646	6,592	0,91	10,168	499,00	2,231	7,393	16,021	878,152	2,5	351,261
	2	1098,4	1138	635	6,525	0,926	10,208	503,00	2,184	9,375	17,819	826,496	2,5	330,598
	3	1105,2	1139,7	636	6,512	0,93	10,183	503,70	2,194	8,941	17,425	916,894	2,5	366,758
Rata-rata									2,203	8,570	17,088	873,847	2,500	349,539
5 %	1	1115,6	1146	646	6,545	0,921	10,18	500,00	2,231	6,687	16,471	1084,776	4	271,194
	2	1104,6	1129,9	620	6,475	0,94	10,168	509,90	2,166	9,401	18,900	1168,717	3,5	333,919
	3	1113,4	1130,2	621	6,525	0,926	10,257	509,20	2,187	8,554	18,142	1058,748	3	352,983
Rata-rata									2,195	8,214	17,837	1104,147	3,500	319,365
5,5 %	1	1099,6	1132,9	629	6,547	0,921	10,15	503,90	2,182	8,034	18,736	684,442	3	228,147
	2	1113,2	1137	634	6,515	0,929	10,192	503,00	2,213	6,730	17,584	897,523	2,5	359,009
	3	1110,8	1134,7	636	6,472	0,94	10,142	498,70	2,227	6,128	17,052	1052,491	3	350,830
Rata-rata									2,208	6,964	17,791	878,152	2,833	312,662
6 %	1	1125,9	1147,3	652	6,545	0,921	10,143	495,30	2,273	3,467	15,795	1046,034	2,5	418,414
	2	1095,8	1121	633	6,535	0,924	10,148	488,00	2,245	4,642	16,821	962,093	2,5	384,837
	3	1122,5	1142,3	646	6,458	0,944	10,13	496,30	2,262	3,952	16,219	929,808	3,5	265,659
Rata-rata									2,260	4,020	16,278	979,312	2,833	356,303
6,5 %	1	1124	1148,6	647	6,498	0,933	10,135	501,60	2,241	4,119	17,435	962,093	3	320,698
	2	1117,2	1142,7	643	6,533	0,924	10,105	499,70	2,236	4,337	17,622	832,953	3,5	237,987
	3	1120,5	1145,6	645	6,448	0,947	10,111	500,60	2,238	4,227	17,527	897,523	3	299,174
Rata-rata									2,238	4,228	17,528	897,523	3,167	285,953
7%	1	1135,1	1155,6	655	6,488	0,926	10,128	500,60	2,267	2,247	16,900	1117,061	3	372,354
	2	1122,1	1140,5	643	6,358	0,994	10,158	497,50	2,255	2,764	17,339	1278,486	2,5	511,394
	3	1125,7	1144,7	646,3	6,495	0,934	10,147	498,40	2,259	2,629	17,224	1201,002	2,5	480,401
Rata-rata									2,261	2,547	17,154	1198,850	2,667	454,716

### Lampiran 5 Hubungan Kadar Aspal dengan Parameter Marshall pada Aspal Pen 60





**Lampiran 6. Komposisi Campuran Beton Aspal pada Aspal Pen 80 ( Benda Uji 1 )**

Ukuran		Berat Jenis (G)			Komposisi Campuran Terhadap Berat Total Campuran (P)						
		Apparent	Bulk		1	2	3	4	5	6	7
½ inch	G1	2,597	2,755	P1	9,60	9,55	9,50	9,45	9,40	9,35	9,30
3/8 inch	G2	2,596	2,761	P2	9,60	9,55	9,50	9,45	9,40	9,35	9,30
No. 4	G3	2,595	2,796	P3	19,20	19,10	19,00	18,90	18,80	18,70	18,60
No. 8	G4	2,206	2,344	P4	16,80	16,71	16,63	16,54	16,45	16,36	16,28
No. 30	G5	2,391	2,542	P5	18,24	18,15	18,05	17,96	17,86	17,77	17,67
No. 50	G6	2,243	2,389	P6	5,28	5,25	5,23	5,20	5,17	5,14	5,12
No. 100	G7	2,402	2,545	P7	5,76	5,73	5,70	5,67	5,64	5,61	5,58
No. 200	G8	2,351	2,497	P8	4,80	4,78	4,75	4,73	4,70	4,68	4,65
Pan	G9	2,68	2,68	P9	6,72	6,69	6,65	6,62	6,58	6,55	6,51
Total Agregat	Gs			Ps	96	95,5	95	94,5	94	93,5	93
Aspal	Gb	1,03	1,03	Pb	4	4,5	5	5,5	6	6,5	7
1 Berat Jenis Bulk (Gsb), Agregat Total					2,5376	2,5376	2,5376	2,5376	2,5376	2,5376	2,5376
2 Berat Jenis Apparent (Gsa), Agregat Total					2,6434	2,6434	2,6434	2,6434	2,6434	2,6434	2,6434
3 Berat Jenis Effectif (Gse), Agregat Total					2,5905	2,5905	2,5905	2,5905	2,5905	2,5905	2,5905
4 Berat Jenis Maksimum (Gmm), Campuran					2,4285	2,4096	2,3911	2,3728	2,3548	2,3371	2,3196
5 Kepadatan (Gmb)					2,143	2,074	2,165	2,265	2,317	2,256	2,286
6 Kadar Aspal Terserap (Pba), (%)					0,8284	0,8284	0,8284	0,8284	0,8284	0,8284	0,8284
7 Kadar Aspal Effectif (Pbe), (%)					3,2048	3,7089	4,2131	4,7172	5,2213	5,7255	6,2296
8 Rongga dalam Agregat (%)					18,924	21,136	18,295	15,658	14,164	16859	16,207
9 Rongga dalam Campuran (%)					11,752	13,934	9,454	4,55	1,597	3,451	1,432

**Lampiran 7. Komposisi Campuran Beton Aspal pada Aspal Pen 80 ( Benda Uji 2 )**

Ukuran		Berat Jenis (G)			Komposisi Campuran Terhadap Berat Total Campuran (P)						
		Apparent	Bulk		1	2	3	4	5	6	7
½ inch	G1	2,597	2,755	P1	9,60	9,55	9,50	9,45	9,40	9,35	9,30
3/8 inch	G2	2,596	2,761	P2	9,60	9,55	9,50	9,45	9,40	9,35	9,30
No. 4	G3	2,595	2,796	P3	19,20	19,10	19,00	18,90	18,80	18,70	18,60
No. 8	G4	2,206	2,344	P4	16,80	16,71	16,63	16,54	16,45	16,36	16,28
No. 30	G5	2,391	2,542	P5	18,24	18,15	18,05	17,96	17,86	17,77	17,67
No. 50	G6	2,243	2,389	P6	5,28	5,25	5,23	5,20	5,17	5,14	5,12
No. 100	G7	2,402	2,545	P7	5,76	5,73	5,70	5,67	5,64	5,61	5,58
No. 200	G8	2,351	2,497	P8	4,80	4,78	4,75	4,73	4,70	4,68	4,65
Pan	G9	2,68	2,68	P9	6,72	6,69	6,65	6,62	6,58	6,55	6,51
Total Agregat	Gs			Ps	96	95,5	95	94,5	94	93,5	93
Aspal	Gb	1,03	1,03	Pb	4	4,5	5	5,5	6	6,5	7
1 Berat Jenis Bulk (Gsb), Agregat Total					2,5376	2,5376	2,5376	2,5376	2,5376	2,5376	2,5376
2 Berat Jenis Apparent (Gsa), Agregat Total					2,6434	2,6434	2,6434	2,6434	2,6434	2,6434	2,6434
3 Berat Jenis Effectif (Gse), Agregat Total					2,5905	2,5905	2,5905	2,5905	2,5905	2,5905	2,5905
4 Berat Jenis Maksimum (Gmm), Campuran					2,4285	2,4096	2,3911	2,3728	2,3548	2,3371	2,3196
5 Kepadatan (Gmb)					2,141	2,154	2,182	2,170	2,305	2,232	2,078
6 Kadar Aspal Terserap (Pba), (%)					0,8284	0,8284	0,8284	0,8284	0,8284	0,8284	0,8284
7 Kadar Aspal Effectif (Pbe), (%)					3,2048	3,7089	4,2131	4,7172	5,2213	5,7255	6,2296
8 Rongga dalam Agregat (%)					19,019	18,107	18,295	19,184	14,632	17,770	23,831
9 Rongga dalam Campuran (%)					11,855	10,628	8,725	8,54	2,133	4,509	10,401



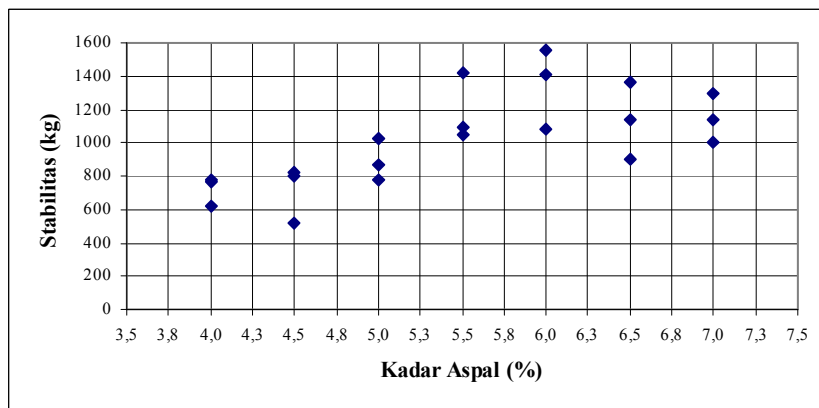
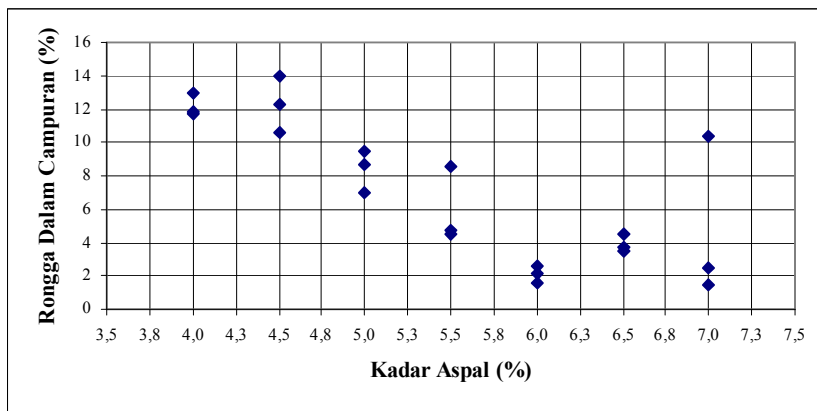
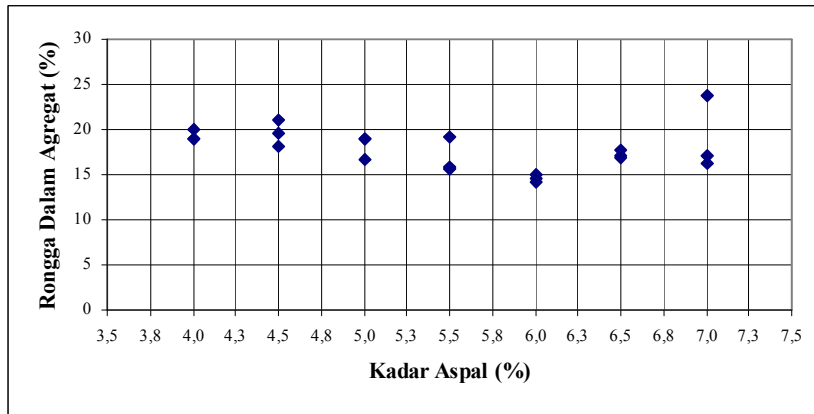
**Lampiran 8. Komposisi Campuran Beton Aspal pada Aspal Pen 80 ( Benda Uji 3 )**

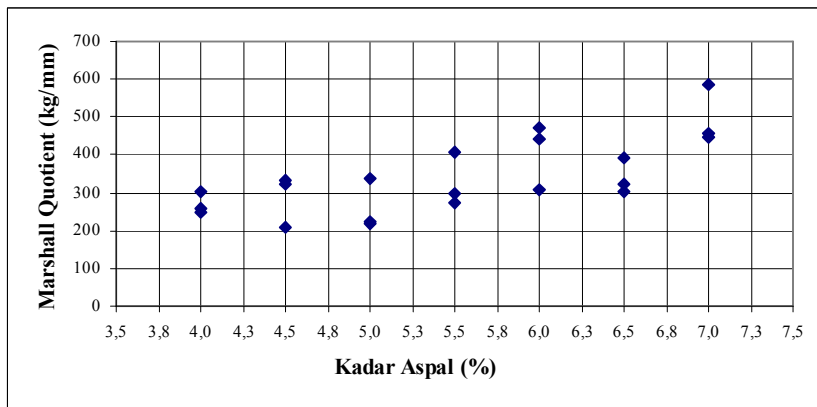
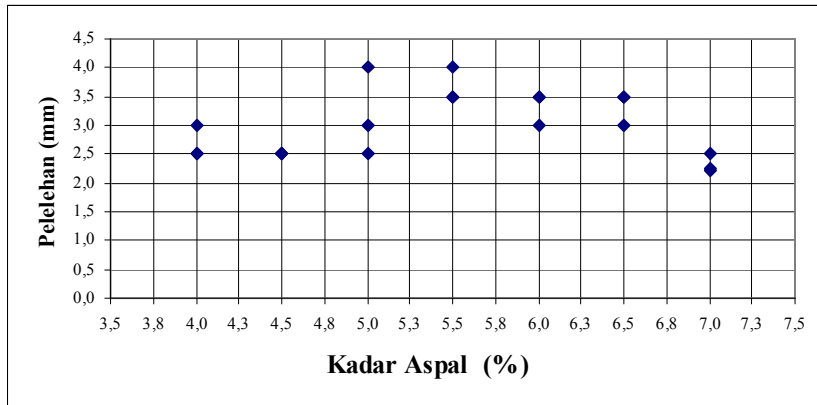
Ukuran		Berat Jenis (G)			Komposisi Campuran Terhadap Berat Total Campuran (P)						
		Apparent	Bulk		1	2	3	4	5	6	7
½ inch	G1	2,597	2,755	P1	9,60	9,55	9,50	9,45	9,40	9,35	9,30
3/8 inch	G2	2,596	2,761	P2	9,60	9,55	9,50	9,45	9,40	9,35	9,30
No. 4	G3	2,595	2,796	P3	19,20	19,10	19,00	18,90	18,80	18,70	18,60
No. 8	G4	2,206	2,344	P4	16,80	16,71	16,63	16,54	16,45	16,36	16,28
No. 30	G5	2,391	2,542	P5	18,24	18,15	18,05	17,96	17,86	17,77	17,67
No. 50	G6	2,243	2,389	P6	5,28	5,25	5,23	5,20	5,17	5,14	5,12
No. 100	G7	2,402	2,545	P7	5,76	5,73	5,70	5,67	5,64	5,61	5,58
No. 200	G8	2,351	2,497	P8	4,80	4,78	4,75	4,73	4,70	4,68	4,65
Pan	G9	2,68	2,68	P9	6,72	6,69	6,65	6,62	6,58	6,55	6,51
Total Agregat	Gs			Ps	96	95,5	95	94,5	94	93,5	93
Aspal	Gb	1,03	1,03	Pb	4	4,5	5	5,5	6	6,5	7
1 Berat Jenis Bulk (Gsb), Agregat Total					2,5376	2,5376	2,5376	2,5376	2,5376	2,5376	2,5376
2 Berat Jenis Apparent (Gsa), Agregat Total					2,6434	2,6434	2,6434	2,6434	2,6434	2,6434	2,6434
3 Berat Jenis Effectif (Gse), Agregat Total					2,5905	2,5905	2,5905	2,5905	2,5905	2,5905	2,5905
4 Berat Jenis Maksimum (Gmm), Campuran					2,4261	2,4070	2,3882	2,3697	2,3515	2,3335	2,3159
5 Kepadatan (Gmb)					2,115	2,113	2,225	2,262	2,293	2,250	2,263
6 Kadar Aspal Terserap (Pba), (%)					0,8284	0,8284	0,8284	0,8284	0,8284	0,8284	0,8284
7 Kadar Aspal Effectif (Pbe), (%)					3,2048	3,7089	4,2131	4,7172	5,2213	5,7255	6,2296
8 Rongga dalam Agregat (%)					19,982	19,666	16,704	15,789	15,071	17,093	1,068
9 Rongga dalam Campuran (%)					12,904	12,330	6,948	4,689	2,636	3,723	2,445

**Lampiran 9. Hasil Percobaan Marshall untuk Memperoleh Kadar Aspal Optimum Menggunakan Aspal Pen 80**

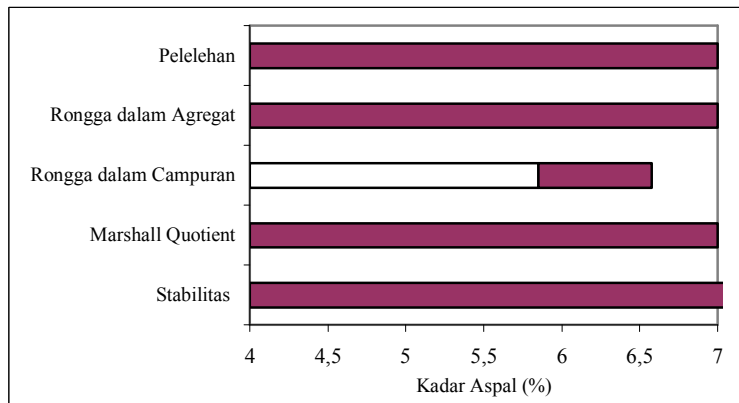
Kadar Aspal (%)	No. Benda Uji	Berat Benda Uji			d (cm)	Angka Korelasi	t (cm)	Bulk Volume (ml)	Kepadatan (gr/ml)	Rongga dalam Campuran (%)	Rongga dalam Agregat (%)	Stabilitas Marshall yang sudah dikoreksi (kg)	Pelelehan (mm)	Marshall Quotient (kg/mm)
		Kering (gr)	Kering Permukaan Jenuh (gr)	Dalam Air (gr)										
4 %	1	1091,7	1135,4	626	6,495	0,934	10,153	525,85	2,143	12,048	19,196	787,754	3	258,280
	2	1096,2	1141,1	629	6,56	0,918	10,232	539,40	2,141	8,974	16,372	736,098	2,5	304,770
	3	1087,6	1127,2	613	6,805	0,865	10,228	559,11	2,115	9,432	16,793	503,646	2,5	247,949
Rata-rata									2,133	10,152	17,454	675,833	2,667	270,333
4,5 %	1	1095,2	1144,1	616	6,732	0,878	10,135	543,10	2,074	7,393	16,021	878,152	2,5	330,598
	2	1104,1	1142,7	630	6,62	0,903	10,172	537,97	2,154	9,375	17,819	826,496	2,5	320,267
	3	1094,7	1156,2	638	6,567	0,916	10,172	533,67	2,113	8,941	17,425	916,894	2,5	206,624
Rata-rata									2,113	8,570	17,088	873,847	2,5	285,830
5 %	1	1105,9	1149,8	639	6,563	0,917	10,227	539,12	2,165	6,687	16,471	1084,776	4	216,310
	2	1106,3	1154,9	648	6,53	0,925	10,168	530,24	2,182	9,401	18,900	1168,717	3,5	221,383
	3	1112,7	1136,1	636	6,505	0,931	10,257	537,50	2,225	8,554	18,142	1058,948	3	340,069
Rata-rata									2,191	8,214	17,837	1104,147	3,5	259,254
5,5 %	1	1114,3	1140	648	6,463	0,943	10,157	523,67	2,265	8,034	18,736	684,442	3,5	298,867
	2	1119,8	1166	650	6,547	0,921	10,2	534,97	2,170	6,730	17,584	897,523	4	274,423
	3	1125,8	1146,8	649	6,465	0,942	10,148	522,90	2,262	6,128	17,052	1052,491	3,5	405,869
Rata-rata									2,232	6,964	17,791	878,152	3,667	326,386
6 %	1	1129,4	1150,4	663	6,46	0,944	10,183	526,11	2,317	3,467	15,795	1046,034	3,5	309,936
	2	1129,7	1150,2	660	6,4	0,96	10,217	524,71	2,305	4,642	16,821	962,093	3	469,209
	3	1117,7	1135,5	648	6,367	0,986	10,178	518,02	2,293	3,952	16,219	929,808	3,5	442,766
Rata-rata									2,305	4,020	16,278	979,312	3,333	407,303
6,5 %	1	1111,3	1141,5	649	6,35	1	10,21	519,89	2,256	4,119	17,435	962,093	3	301,327
	2	1120,1	1138,9	637	6,426	0,953	10,21	526,12	2,232	4,337	17,622	832,953	3,5	391,110
	3	1120,1	1144,8	647	6,448	0,947	10,218	528,75	2,250	4,227	17,527	897,523	3,5	324,695
Rata-rata									2,246	4,228	17,528	897,523	3,333	339,044
7%	1	1136,1	1153,9	657	6,542	0,922	10,18	532,47	2,286	2,247	16,900	1117,061	2,21	584,344
	2	1034,6	1151,8	654	6,54	0,923	10,213	535,76	2,078	2,764	17,339	1278,486	2,5	454,573
	3	1124,2	1144,8	648	6,358	0,994	10,153	514,75	2,263	2,629	17,224	1201,002	2,25	447,685
Rata-rata									2,209	2,547	17,154	1198,850	2,320	495,534

### Lampiran 10 Hubungan Kadar Aspal dengan Parameter Marshall dengan Aspal Pen 80



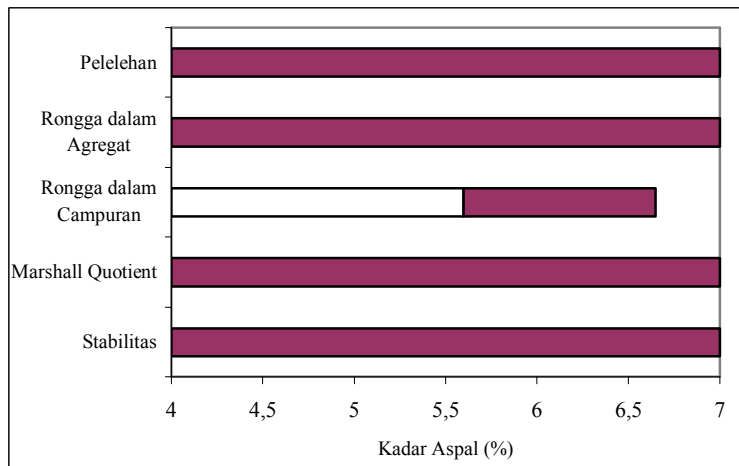


### Lampiran 11 Kadar Aspal Optimum



#### Kadar Aspal Optimum untuk Aspal Pen 80

$$\text{Kadar Aspal Optimum} = \frac{5,6 + 6,7}{2} = 6,2 \%$$



#### Kadar Aspal Optimum untuk Aspal Pen 60

$$\text{Kadar Aspal Optimum} = \frac{5,9 + 6,6}{2} = 6,3 \%$$

## Lampiran 12 Contoh Perhitungan Komposisi Campuran Marshall

Komposisi Campuran Terhadap Berat Total Campuran

Berat campuran = 1100 gram

% Aspal = 6 %

% Agregat = 94 % → Berat Agregat = 94 % × 1100 = 1034 gram

Berat agregat masing-masing saringan = Persentase × Berat agregat

Berat agregat tertahan saringan no ½ inch = 10% × 1034 = 103,4 gram

Berat agregat lolos ½ inch tertahan saringan no 3/8 inch = 10% × 1034 = 103,4 gram

Berat agregat lolos no 3/8 inch tertahan saringan no.4 = 20% × 1034 = 206,8 gram

Berat agregat lolos no 4 tertahan saringan no.8 = 17,5% × 1034 = 180,95 gram

Berat agregat lolos no 8 tertahan saringan no.30 = 19% × 1034 = 196,46 gram

Berat agregat lolos no 30 tertahan saringan no.50 = 5,5% × 1034 = 56,870 gram

Berat agregat lolos no 50 tertahan saringan no.100 = 6% × 1034 = 62,040 gram

Berat agregat lolos no 100 tertahan saringan no.200 = 5% × 1034 = 51,7 gram

Berat agregat lolos no 200 tertahan saringan Pan = 7% × 1034 = 72,380 gram

$$P_1 = \frac{103,4}{1100} \times 100\% = 9,4\%$$

$$P_2 = \frac{103,4}{1100} \times 100\% = 9,4\%$$

$$P_3 = \frac{206,8}{1100} \times 100\% = 18,8\%$$

$$P_4 = \frac{180,950}{1100} \times 100\% = 16,45\%$$

$$P_5 = \frac{194,60}{1100} \times 100\% = 17,691\%$$

$$P_6 = \frac{56,870}{1100} \times 100\% = 5,162\%$$

$$P_7 = \frac{62,040}{1100} \times 100\% = 5,640\%$$

$$P_8 = \frac{51,7}{1100} \times 100\% = 4,7\%$$

$$P_9 = \frac{72,380}{1100} \times 100\% = 6,580\%$$

#### 1. Berat Jenis Bulk (Gsb)

$$Gsb = \frac{P_1 + P_2 + \dots + P_n}{\frac{P_1}{Gsb_1} + \frac{P_2}{Gsb_2} + \dots + \frac{P_n}{Gsb_n}}$$

dengan :

$P_1, P_2, \dots, P_n$  = persen berat agregat ke-1, 2, dan ke-n terhadap berat total campuran

$Gsb_1, Gsb_2, \dots, Gsb_n$  = Bulk Specific Gravity fraksi agregat ke-1, 2, dan ke-n

$$Gsb = \frac{9,4 + 9,4 + 18,8 + 16,45 + 17,691 + 5,162 + 5,640 + 4,7 + 6,58}{\frac{9,4}{2,374} + \frac{9,4}{2,458} + \frac{18,8}{2,713} + \frac{16,45}{2,538} + \frac{17,691}{2,486} + \frac{5,162}{2,472} + \frac{5,640}{2,521} + \frac{4,7}{2,501} + \frac{6,58}{2,68}}$$

$$= 2,5376$$

## 2. Berat Jenis Apparent (Gsa)

$$Gsa = \frac{P_1 + P_2 + \dots + P_n}{\frac{P_1}{Gsa_1} + \frac{P_2}{Gsa_2} + \dots + \frac{P_n}{Gsa_n}}$$

dengan :

$P_1, P_2, \dots, P_n$  = persen berat agregat ke-1, 2, dan ke-n terhadap berat total campuran

$Gsa_1, Gsa_2, \dots, Gsa_n$  = Apparent Specific Gravity fraksi agregat ke-1, 2, dan ke-n

$$Gsa = \frac{9,4 + 9,4 + 18,8 + 16,45 + 17,691 + 5,162 + 5,640 + 4,7 + 6,58}{\frac{9,4}{2,483} + \frac{9,4}{2,576} + \frac{18,8}{2,840} + \frac{16,45}{2,647} + \frac{17,691}{2,597} + \frac{5,162}{2,580} + \frac{5,640}{2,623} + \frac{4,7}{2,623} + \frac{6,58}{2,68}}$$

$$= 2,6484$$

## 3. Berat Jenis Effective (Gse)

$$Gse = \frac{Gsb + Gsa}{2}$$

dengan :

$Gsb$  = Berat jenis Bulk agregat

$Gsa$  = Berat jenis Apparent agregat

$$Gse = \frac{2,5376 + 2,6484}{2} = 2,5905$$



## 4. Berat Jenis Maksimum (Gmm)

$$G_{mm} = \frac{P_{mm}}{\frac{P_s}{G_{se}} + \frac{P_b}{G_b}}$$

dengan :

$$P_{mm} = 100\%$$

$P_s$  = Total persen agregat terhadap berat total campuran

$P_b$  = Persen aspal terhadap berat total campuran

$G_{se}$  = Berat jenis Effective agregat

$G_b$  = Berat jenis aspal

$$G_{mm} = \frac{100}{\frac{94}{2,5905} + \frac{6}{1,03}} = 2,3548$$

## 5. Kepadatan (Gmb)

Kepadatan diperoleh dari :

Berat kering = 1125,9 gram

Berat kering permukaan jenuh = 1147,3 gram

Berat dalam air = 652 gram

Sehingga :

Bulk Volume = Berat kering permukaan jenuh – Berat dalam air

$$= 1147,3 - 652$$

$$= 495,3 \text{ gram}$$

$$= \frac{495,3 \text{ gram}}{\gamma_{\text{air}}}$$

$$= \frac{495,3 \text{ gram}}{1 \text{ gram/cm}^3}$$

$$= 495,3 \text{ cm}^3$$

$$G_{mb} = \frac{\text{Berat kering}}{\text{BulkVolume}}$$

$$= \frac{1125,9}{495,3}$$

$$= 2,273$$

6. Kadar Aspal Terserap (Pba)

$$\begin{aligned} P_{ba} &= 100 \times \frac{(G_{se} - G_{sb})}{(G_{se} \times G_{sb})} \times G_b \\ &= 100 \times \frac{(2,5905 - 2,5376)}{(2,5905 \times 2,5376)} \times 1,03 \\ &= 0,8284 \% \end{aligned}$$

7. Kadar Aspal Effective (Pbe)

$$\begin{aligned} P_{be} &= P_b - \frac{P_{ba}}{100} \times P_s \\ &= 6 - \frac{0,8284}{100} \times 94 \\ &= 5,2213 \% \end{aligned}$$

## 8. Rongga Dalam Agregat ( VMA)

$$\begin{aligned} \text{VMA} &= 100 - \frac{\text{Gmb} \times \text{Ps}}{\text{Gsb}} \\ &= 100 - \frac{2,273 \times 94}{2,5376} \\ &= 15,735 \% \end{aligned}$$

## 9. Rongga Dalam Campuran ( Pa)

$$\begin{aligned} \text{Pa} &= 100 \times \frac{\text{Gmm} - \text{Gmb}}{\text{Gmm}} \\ &= 100 \times \frac{2,3548 - 2,273}{2,3548} \\ &= 3,467 \% \end{aligned}$$

**Lampiran 13. Hasil Uji Kuat Tarik Tidak Langsung untuk Aspal Pen 60**

Lama Perendaman	No Sampel	Tinggi Sampel (cm)	Diameter Sampel (cm)	Pmaks (kg)	Kuat Tarik Tidak Langsung (kg/cm <sup>2</sup> )
0 hari	1	6,345	10,157	1036,58	10,24
	2	6,343	10,150	1076,44	10,64
	3	6,350	10,153	1010,01	9,97
	4	6,353	10,152	970,15	9,58
	5	6,343	10,153	930,29	9,20
Rata-rata					9,93
1 hari	6	6,340	10,151	1010,01	9,99
	7	6,341	10,152	983,44	9,73
	8	6,350	10,149	930,29	9,19
	9	6,348	10,150	797,97	7,88
	10	6,403	10,152	903,72	8,85
Rata-rata					9,13

**Lampiran 14. Hasil Uji Kuat Tarik Tidak Langsung untuk Aspal Pen 80**

Lama Perendaman	No Sampel	Tinggi Sampel (cm)	Diameter Sampel (cm)	Pmaks (kg)	Kuat Tarik Tidak Langsung (kg/cm <sup>2</sup> )
0 hari	1	6,347	10,154	824,41	8,14
	2	6,352	10,148	771,54	7,62
	3	6,350	10,155	811,19	8,01
	4	6,345	10,157	745,11	7,36
	5	6,355	10,146	850,83	8,40
Rata-rata					7,91
1 hari	6	6,354	10,147	797,97	7,88
	7	6,349	10,152	758,32	7,49
	8	6,353	10,156	771,54	7,61
	9	6,352	10,160	666,12	6,57
	10	6,349	10,158	718,68	7,09
Rata-rata					7,33

**Lampiran 15 Perhitungan Kuat Tarik Tidak Langsung Dengan Menggunakan Aspal Penetrasi 60**

Lama Perendaman	No Benda Uji	d (cm)	t (cm)	Pembacaan Alat (divisi)	Beban Maksimum (kg)	Kuat Tarik Tidak Langsung (kg/cm <sup>2</sup> )
0 hari	1	6,345	10,157	400	1036,58	10,24
	2	6,343	10,150	415	1076,44	10,64
	3	6,350	10,153	390	1010,01	9,97
	4	6,353	10,152	375	970,15	9,58
	5	6,343	10,153	360	930,29	9,20
1 hari	6	6,340	10,151	390	1010,01	9,99
	7	6,341	10,152	380	983,44	9,73
	8	6,350	10,149	360	930,29	9,19
	9	6,348	10,150	310	797,97	7,88
	10	6,403	10,152	350	903,72	8,85

$$\begin{aligned} \text{Kuat Tarik Tidak Langsung (S}_{t_1}) &= \frac{2 \times 1036,58}{\pi \times 6,345 \times 10,157} \\ &= 10,24 \text{ kg/cm}^2 \end{aligned}$$

**Lampiran 16 Perhitungan Kuat Tarik Tidak Langsung Dengan Menggunakan Aspal Penetrasi 80**

Lama Perendaman	No Benda Uji	d (cm)	t (cm)	Pembacaan Alat (divisi)	Beban Maksimum (kg)	Kuat Tarik Tidak Langsung (kg/cm <sup>2</sup> )
0 hari	1	6,347	10,154	320	824,41	8,14
	2	6,352	10,148	300	771,54	7,62
	3	6,350	10,155	315	811,19	8,01
	4	6,345	10,157	290	745,11	7,36
	5	6,355	10,146	330	850,83	8,40
1 hari	6	6,354	10,147	310	797,97	7,88
	7	6,349	10,152	295	758,32	7,49
	8	6,353	10,156	300	771,54	7,61
	9	6,352	10,160	285	666,12	6,57
	10	6,349	10,158	280	718,68	7,09

$$\begin{aligned} \text{Kuat Tarik Tidak Langsung (S}_{t_1}) &= \frac{2 \times 824,41}{\pi \times 6,347 \times 10,154} \\ &= 8,14 \text{ kg/cm}^2 \end{aligned}$$

### Lampiran 17. Perhitungan Uji – t Kuat Tarik Tidak Langsung Tanpa Perendaman

$$H_0 : \mu_A = \mu_B$$

$$H_a : \mu_A > \mu_B$$

$H_0$  ditolak bila  $t > t_{\alpha}$

dimana :

$\mu_A$  : Kuat Tarik Tidak Langsung Beton Aspal dengan menggunakan aspal penetrasi 60

$\mu_B$  : Kuat Tarik Tidak Langsung Beton Aspal dengan menggunakan aspal penetrasi 80

Umur Perendaman	Kuat Tarik Tidak Langsung (kg/cm <sup>2</sup> )		Y <sub>Ai</sub> <sup>2</sup>	Y <sub>Bi</sub> <sup>2</sup>
	Aspal Pen 60 (Y <sub>Ai</sub> )	Aspal Pen 80 (Y <sub>Bi</sub> )		
0 hari	10,24	8,14	104,86	66,26
	10,64	7,62	113,21	58,06
	9,97	8,01	99,40	64,16
	9,58	7,36	91,78	54,17
	9,20	8,40	84,64	70,56
Σ	49,63	39,53	493,89	313,21

$$n = 5$$

$$\bar{Y}_1 = \frac{\sum_{i=1}^n Y_{A_i}}{n} = \frac{49,63}{5} = 9,93$$

$$\bar{Y}_2 = \frac{\sum_{i=1}^n Y_{B_i}}{n} = \frac{39,53}{5} = 7,91$$

$$S_1 = \sqrt{\frac{n \sum_{i=1}^n Y_{A_i}^2 - \sum_{i=1}^n (Y_{A_i})^2}{n(n-1)}} = \sqrt{\frac{(5 \times 493,89) - (49,63)^2}{5(5-1)}} = 0,56$$

$$S_2 = \sqrt{\frac{n \sum_{i=1}^n Y_{B_i}^2 - \sum_{i=1}^n (Y_{B_i})^2}{n(n-1)}} = \sqrt{\frac{(5 \times 313,21) - (39,53)^2}{5(5-1)}} = 0,41$$

$$S_p = \sqrt{\frac{(n_1 - 1)(S_1^2) + (n_2 - 1)(S_2^2)}{n_1(n_2 - 2)}} = \sqrt{\frac{(4 \times 0,56^2) + (4 \times 0,41^2)}{5(5-2)}} = 0,49$$

$$t = \frac{(\bar{Y}_A - \bar{Y}_B)}{S_p \left( \sqrt{\frac{1}{n_1} + \frac{1}{n_2}} \right)} = \frac{(9,93 - 7,91)}{0,49 \times \sqrt{\frac{1}{5} + \frac{1}{5}}} = 6,52$$

$$df = n_1 + n_2 - 2 = 5 + 5 - 2 = 8$$

$$\alpha = 0,05$$

$t_{0,05;4} = 1,860$  ( dari Tabel distribusi t pada Lampiran 19 )

$t = 6,52 > t_{0,05;4} = 1,860$ , maka  $H_0$  ditolak, sehingga disimpulkan bahwa nilai kuat tarik tidak langsung beton aspal yang menggunakan aspal penetrasi 60 lebih besar daripada yang menggunakan aspal penetrasi 80

**Lampiran 18. Perhitungan Uji – t Kuat Tarik Tidak Langsung Dengan Perendaman (1 hari)**

$$H_0 : \mu_A = \mu_B$$

$$H_a : \mu_A > \mu_B$$

$H_0$  ditolak bila  $t > t_\alpha$

dimana :

$\mu_A$  : Kuat Tarik Tidak Langsung Beton Aspal dengan menggunakan aspal penetrasi 60

$\mu_B$  : Kuat Tarik Tidak Langsung Beton Aspal dengan menggunakan aspal penetrasi 80

Umur Perendaman	Kuat Tarik Tidak Langsung (kg/cm <sup>2</sup> )		$Y_{Ai}^2$	$Y_{Bi}^2$
	Aspal Pen 60 ( $Y_{Ai}$ )	Aspal Pen 80 ( $Y_{Bi}$ )		
0 hari	9,99	7,88	99,8	62,1
	9,73	7,49	94,7	56,1
	9,19	7,61	84,5	84,5
	7,88	6,57	62,1	43,2
	8,85	7,09	78,3	50,3
$\Sigma$	45,64	36,64	419,4	296,2

$$n = 5$$

$$\bar{Y}_1 = \frac{\sum_{i=1}^n Y_{Ai}}{n} = \frac{45,64}{5} = 9,13$$

$$\bar{Y}_2 = \frac{\sum_{i=1}^n Y_{Bi}}{n} = \frac{36,64}{5} = 7,33$$



$$S_1 = \sqrt{\frac{n \sum_{i=1}^n Y_{A_i}^2 - \sum_{i=1}^n (Y_{A_i})^2}{n(n-1)}} = \sqrt{\frac{(5 \times 419,4) - (45,64)^2}{5(5-1)}} = 0,83$$

$$S_2 = \sqrt{\frac{n \sum_{i=1}^n Y_{B_i}^2 - \sum_{i=1}^n (Y_{B_i})^2}{n(n-1)}} = \sqrt{\frac{(5 \times 296,2) - (36,64)^2}{5(5-1)}} = 0,51$$

$$S_p = \sqrt{\frac{(n_1 - 1)(S_1^2) + (n_2 - 1)(S_2^2)}{n_1(n_2 - 2)}} = \sqrt{\frac{(4 \times 0,83^2) + (4 \times 0,51^2)}{5(5-2)}} = 0,69$$

$$t = \frac{(\bar{Y}_A - \bar{Y}_B)}{S_p \left( \sqrt{\frac{1}{n_1} + \frac{1}{n_2}} \right)} = \frac{(9,13 - 7,33)}{0,69 \times \sqrt{\frac{1}{5} + \frac{1}{5}}} = 4,15$$

$$df = n_1 + n_2 - 2 = 5 + 5 - 2 = 8$$

$$\alpha = 0,05$$

$t_{0,05; 4} = 1,860$  ( dari Tabel distribusi t pada Lampiran 19 )

$t = 4,15 > t_{0,05; 4} = 1,860$ , maka  $H_0$  ditolak, sehingga disimpulkan bahwa nilai kuat tarik tidak langsung beton aspal yang menggunakan aspal penetrasi 60 lebih besar daripada yang menggunakan aspal penetrasi 80

Lampiran 19 Tabel Koreksi Nilai Stabilitas

Isi Benda Uji (cm <sup>3</sup> )	Tinggi Benda Uji		Angka Koreksi
	Inchi	mm	
200-213	1	2,54	5,56
214-225	1 1/16	2,70	5
226-237	1 2/16	2,86	4,55
238-250	1 3/16	3,02	4,17
252-264	1 4/16	3,18	3,86
265-276	1 5/16	3,33	3,57
277-289	1 6/16	3,49	3,33
290-301	1 7/16	3,65	3,03
302-316	1 8/16	3,81	2,78
317-328	1 9/16	3,97	2,5
329-340	1 10/16	4,13	2,27
342-353	1 11/16	4,29	2,08
354-367	1 12/16	4,45	1,92
368-379	1 13/16	4,60	1,79
380-392	1 14/16	4,76	1,67
393-405	1 15/16	4,92	1,56
406-420	2	5,08	1,47
422-431	2 1/16	5,24	1,39
432-443	2 2/16	5,40	1,32
444-456	2 3/16	5,56	1,25
457-470	2 4/16	5,72	1,19
472-482	2 5/16	5,87	1,14
483-495	2 6/16	6,03	1,09
496-508	2 7/16	6,19	1,04
509-522	2 8/16	6,35	1
523-535	2 9/16	6,51	0,96
536-546	2 10/16	6,67	0,93
547-559	2 11/16	6,83	0,89
560-573	2 12/16	6,99	0,86
574-585	2 13/16	7,14	0,83
586-598	2 14/16	7,30	0,81
599-610	2 15/16	7,46	0,78
612-625	3	7,62	0,76

**Lampiran 20 Tabel Distribusi t**