LAMPIRAN I
PEMERIKSAAN AGREGAT

Tabel L1.1 Hasil Pengujian Berat Jenis Agregat Kasar

Jenis Pengujian	Ukuran Saringan			
	$^1/_2$"	$^3/_8$"	No. 4	No. 8
Berat Benda Uji Kering Oven (Bk) (gr)	1081,0	1088,8	1188,5	1264,6
Berat Benda Uji Kering Permukaan Jenuh (Bj)(gr)	1115,2	1130,4	1228,1	1304,0
Berat Benda Uji Dalam Air (Ba) (gr)	685	698	753	801
Berat Jenis (*Bulk*) $\frac{Bk}{Bj - Ba}$	2,513	2,519	2,502	2,514
Berat Jenis Permukaan Jenuh $\frac{Bj}{(Bj - Ba)}$	2,592	2,614	2,585	2,592
Berat Jenis Semu (*Apparent*) $\frac{Bk}{(Bk - Ba)}$	2,730	2,788	2,729	2,728
Penyerapan (*Absorption*) (%) $\frac{Bj - Bk}{Bk} \times 100\ \%$	3,164	3,859	3,332	3,116
Berat Jenis Efektif = $\frac{(Bulk) + (Apparent)}{2}$	2,622	2,654	2,616	2,621

Tabel L1.2 Hasil Pengujian Berat Jenis Agregat Halus

Jenis Pengujian	Nomor Saringan					
	16	30	40	50	100	200
Berat Benda Uji Kering Permukaan Jenuh (Bssd) (gr)	500	500	500	500	500	500
Berat Benda Uji Kering Oven (Bk) (gr)	484,0	491,2	485	484,0	490,0	485,4
Berat Piknometer Diisi Air (25°C) (B) (gr)	649,5	648,8	658,5	658,3	654,4	657,3
Berat Piknometer + Benda Uji (ssd) + air (25°C) (Bt) (gr)	954,5	956,5	966,9	963,1	956,3	957,4
Berat Jenis (*Bulk*) $\frac{Bk}{(B+500-Bt)}$	2.482	2.554	2,531	2.480	2.473	2.428
Berat Jenis Permukaan Jenuh $\frac{500}{(B+500-Bt)}$	2.564	2.600	2,610	2.561	2.524	2.501
Berat Jenis Semu (*Apparent*) $\frac{Bk}{(B+500-Bt)}$	2.704	2.677	2,750	2.701	2.605	2.619
Penyerapan (*Absorption*) (%) $\frac{(500-Bk)}{Bk} x\,100\%$	3.306	1.792	3,090	3.306	2.041	3.001
Berat Jenis Efektif $= \frac{(Bulk)+(Apparent)}{2}$	2.593	2.611	2,640	2.591	2.539	2.524

Tabel L1.3 Hasil Pengujian Berat Jenis *Filler* Abu Batu

Jenis Pengujian	Hasil (gr)
Berat Piknometer + Contoh (W2)	87,2
Berat Piknometer (W1)	37,2
Berat Tanah (Wt = W2-W1)	50
Temperatur t°C	25
Berat Piknometer + Air + Tanah Pada Suhu 25°C (W3)	167,6
Berat Piknometer + Air Pada 25°C (W4)	137,2
W5 = W2 - W1 + W4	187,2
Isi Tanah (W5-W3)	19,6
Berat Jenis $\left(\frac{Wt}{W5 - W3}\right)$	2,551

Tabel L1.4 Hasil Pengujian Berat Jenis *Filler* Spen Katalis

Jenis Pengujian	Hasil (gr)
Berat Piknometer + Contoh (W2)	86,8
Berat Piknometer (W1)	36,8
Berat Tanah (Wt = W2-W1)	50
Temperatur t °C	25
Berat Piknometer + Air + Tanah Pada Suhu 25 °C (W3)	164,7
Berat Piknometer + Air Pada 25 °C (W4)	136,4
W5 = W2 - W1 + W4	186,4
Isi Tanah (W5-W3)	21,7
Berat Jenis $\left(\frac{Wt}{W5 - W3}\right)$	2,304

LAMPIRAN II
PEMERIKSAAN ASPAL

Tabel L2.1 Hasil Pengujian Penetrasi

Penetrasi pada 25°C 100 gr, 5 detik	Pengamatan I (0,1 mm)	Pengamatan II (0,1 mm)
Pengamatan ke-1	65	67
Pengamatan ke-2	67	68
Pengamatan ke-3	72	63
Pengamatan ke-4	61	72
Pengamatan ke-5	64	62
Rata-rata	65,80	66,40

Tabel L2.2 Hasil Pengujian Titik Lembek

No.	Suhu yang diamati °C	Pengamatan I		Pengamatan II	
		Waktu (detik)	Titik Lembek °C	Waktu (detik)	Titik Lembek °C
1	25	0:00		0:00	
2	30	1:29		1:36	
3	35	2:32		2:22	
4	40	4:05		3:49	
5	45	4:45		4:37	
6	50	5:45		5:51	
7		6:05	53	6:12	51

Tabel L2.3 Hasil Pengujian Daktilitas

Sampel Ke-	Panjang Saat Putus (cm)
I	> 100
II	> 100
III	> 100

Tabel L2.4 Hasil Pengujian Titik Nyala dan Titik Bakar (Perkiraan 350°C)

°C di bawah Titik Nyala	Waktu	°C	Keterangan
56	0	294	
51	1	299	
46	2	304	
40	3	310	
36	4	314	
31	5	319	
25	6	325	
20	7	330	
16	8	334	
14	9	336	Titik Nyala
11	10	339	Titik Bakar

Tabel L2.5 Pemeriksaan Berat Jenis Aspal

Benda Uji	I	II
Berat piknometer + contoh (gr)	57,8	55,2
Berat piknometer (gr)	46,3	35,5
1. Berat contoh (gr)	11,5	19,7
Berat piknometer + air (gr)	141,8	134,6
Berat piknometer (gr)	46,3	35,5
2. Berat air (gr)	95,5	99,1
Berat piknometer+ contoh + air (gr)	153,3	135,5
Berat piknometer+ contoh (gr)	57,8	55,2
3. Isi air (gr)	84,4	80,28
Isi contoh (2- 3) (gr)	11,1	18,82
Berat jenis = $\frac{\text{Berat contoh}}{\text{Isi contoh}}$	1,036	1,047
Berat Jenis Rata-rata	1,042	

LAMPIRAN III
PENENTUAN BERAT BENDA UJI

Tabel L3.1 Penentuan Berat Aspal , Bahan Pengisi, dan Agregat

Kadar Aspal (%)	Berat Aspal (gr)	Berat Bahan Pengisi (gr)			Berat Agregat (gr)	Total Berat Campuran (gr)
		100% Abu Batu	25% Spen Katalis	75% Spen Katalis		
8	88	91,080	22,770	68,310	1012	1100
8,5	93,5	90,585	22,646	67,939	1006,5	1100
9	99	90,090	22,523	67,568	1001	1100
9,5	104,5	89,595	22,399	67,196	995,5	1100
10	110	89,100	44,550	89,100	990	1100

- KAA = (0,035 x 39) + (0,045 x 52) + (0,18 x 9) + 3
  = 8,325% ≈ 8,5%
- Kadar aspal yang akan dicoba: 8%, 8,5%, 9%, 9,5%, 10%
- Diperkirakan berat campuran = 1100 gram
- Berat aspal = Kadar aspal x Total berat campuran
- Berat agregat = Total berat campuran – Berat aspal

Tabel L3.2 Penentuan Berat Agregat pada Kadar Aspal 8%

Ukuran Saringan	Persentase Lolos (%)	Persen Tertahan (%)	Berat/1 Benda Uji (gr)
¾ inci	100	-	-
½ inci	95	5	50,60
$^{3}/_{8}$ inci	80	15	151,80
No. 4	71	10	101,20
No. 8	61	9	91,08
No.16	55,5	7	70,84
No.30	50	4	40,48
No. 40	43	7	70,84
No. 50	36	6	60,72
No. 100	23	14	141,68
No. 200	9	14	141,68
filler	-	9	91,08

Tabel L3.3 Penentuan Berat Agregat pada Kadar Aspal 8,5 %

Ukuran Saringan	Persentase Lolos (%)	Persen Tertahan (%)	Berat/1 Benda Uji (gr)
¾ inci	100	-	-
½ inci	95	5	50,325
$^{3}/_{8}$ inci	80	15	150,750
No. 4	71	10	100,650
No. 8	61	9	90,585
No.16	55,5	7	70,455
No.30	50	4	40,260
No. 40	43	7	70,455
No. 50	36	6	60,390
No. 100	23	14	140,910
No. 200	9	14	140,910
filler	-	9	90,585

Tabel L3.4 Penentuan Berat Agregat pada Kadar Aspal 9%

Ukuran Saringan	Persentase Lolos (%)	Persen Tertahan (%)	Berat/1 Benda Uji (gr)
¾ inci	100	-	-
½ inci	95	5	50,05
$^{3}/_{8}$ inci	80	15	150,15
No. 4	71	10	100,10
No. 8	61	9	90,09
No.16	55,5	7	70,07
No.30	50	4	40,04
No. 40	43	7	70,07
No. 50	36	6	60,06
No. 100	23	14	140,14
No. 200	9	14	140,14
filler	-	9	90,09

Tabel L3.5 Penentuan Berat Agregat pada Kadar Aspal 9,5%

Ukuran Saringan	Persentase Lolos (%)	Persen Tertahan (%)	Berat/1 Benda Uji (gr)
¾ inci	100	-	-
½ inci	95	5	49,775
$^{3}/_{8}$ inci	80	15	149,325
No. 4	71	10	99,550
No. 8	61	9	89,595
No.16	55,5	7	69,685
No.30	50	4	39,820
No. 40	43	7	69,685
No. 50	36	6	59,730
No. 100	23	14	139,730
No. 200	9	14	139,370
filler	-	9	89,595

Tabel L3.6 Penentuan Berat Agregat pada Kadar Aspal 10%

Ukuran Saringan	Persentase Lolos (%)	Persen Tertahan (%)	Berat/1 Benda Uji (gr)
¾ inci	100	-	-
½ inci	95	5	49,5
$^{3}/_{8}$ inci	80	15	148,5
No. 4	71	10	99,0
No. 8	61	9	89,1
No.16	55,5	7	69,3
No.30	50	4	39,6
No. 40	43	7	69,3
No. 50	36	6	59,4
No. 100	23	14	138,6
No. 200	9	14	138,6
filler	-	9	89,1

LAMPIRAN IV
HASIL PENGUJIAN MARSHALL

Tabel L4.1 Hasil Pengujian Marshall untuk *Filler* Spen Katalis 0%

Tabel L4.2 Hasil Pengujian Marshall untuk *Filler* Spen Katalis 0% *

Tabel L4.3 Hasil Pengujian Marshall untuk *Filler* Spen Katalis 25%

Tabel L4.4 Hasil Pengujian Marshall untuk *Filler* Spen Katalis 50% *

Tabel L4.5 Hasil Pengujian Marshall untuk *Filler* Spen Katalis 75%

Tabel L4.6 Hasil Pengujian Marshall untuk *Filler* Spen Katalis 100% *

Keterangan: * = data dari hasil penelitian Apriyadi

Tabel L4.1 Hasil Pengujian Marshall untuk *Filler* Spen Katalis 0%

Tanggal :	Agregat	Aspal
Jenis Campuran : 100% abu batu	Berat jenis bulk (gsb) : 2,497	Penetrasi : 60
	Berat jenis apparent : 2,683	Berat jenis (S) : 1,042

No. Benda Uji	Kadar Aspal		Berat Jenis		Berat (gram)			Volume bulk (cm³)	Berat jenis bulk (Gmb)	% Volume		% Pori			Stabilitas			Flow (mm)
	% Berat terhadap total agregat	% berat terhadap total campuran	Gse	Gmm	Di Udara	Dlm air	Kering Permukaan (ssd)			Aspal thdp campuran	Agregat efektif thdp campuran	VMA	VIM	VFA	Bacaan dial	Justifikasi (kg)	Koreksi Volume	
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	8.696	8	2.591	2.316	1064.3	577	1069.0	492.0	2.163	16.640	76.814	20.307	6.578	67.606	1247	1527.25	1573.068	5.72
2	8.696	8	2.591	2.316	1073.0	583	1079.0	496.0	2.163	16.641	76.817	20.304	6.574	67.621	1308	1599.52	1663.501	5.86
3	8.696	8	2.591	2.316	1062.6	583	1075.8	492.8	2.156	16.587	76.566	20.564	6.879	66.548	1287	1574.68	1621.920	5.55
1	9.290	8.5	2.591	2.300	1054.7	573	1059.8	486.8	2.167	17.708	76.516	20.616	5.810	71.816	1352	1651.65	1800.299	5.84
2	9.290	8.5	2.591	2.300	1057.2	575	1061.7	486.7	2.172	17.753	76.713	20.412	5.568	72.723	1305	1595.97	1739.607	5.16
3	9.290	8.5	2.591	2.300	1057.8	578	1062.9	484.9	2.181	17.829	77.041	20.071	5.163	74.274	1510	1839.28	2004.815	5.54
1	9.890	9	2.591	2.285	1063.6	580	1068.5	488.5	2.177	18.842	76.473	20.661	4.722	77.147	1325	1619.66	1765.429	4.39
2	9.890	9	2.591	2.285	1065.8	582	1070.7	488.7	2.181	18.873	76.600	20.529	4.564	77.770	1281	1567.53	1708.608	4.5
3	9.890	9	2.591	2.285	1065.5	582	1070.3	488.3	2.182	18.883	76.641	20.487	4.512	77.974	1445	1761.90	1920.471	4.62
1	10.497	9.5	2.591	2.270	1056.0	578	1061.4	483.4	2.185	19.955	76.306	20.834	3.778	81.868	1759	2137.68	2330.071	5.2
2	10.497	9.5	2.591	2.270	1062.6	580	1067.4	487.4	2.180	19.915	76.153	20.993	3.971	81.084	1574	1915.47	2087.862	5.41
3	10.497	9.5	2.591	2.270	1062.6	583	1067.5	484.5	2.193	20.034	76.608	20.520	3.396	83.450	1760	2138.88	2331.379	5.78
1	11.111	10	2.591	2.256	1072.6	598	1086.6	488.6	2.195	21.108	76.257	20.885	2.676	87.189	1531	1864.28	2032.065	5.81
2	11.111	10	2.591	2.256	1082.0	592	1087.3	495.3	2.185	21.005	75.884	21.271	3.151	85.188	1477	1800.00	1962.000	5.77
3	11.111	10	2.591	2.256	1071.9	589	1077.9	488.9	2.192	21.081	76.160	20.985	2.799	86.663	1521	1852.38	2019.094	5.98

Tabel L4.2 Hasil Pengujian Marshall untuk *Filler* Spen Katalis 0% [Apriyadi, 2009]

Tanggal :	Agregat	Aspal
Jenis Campuran : 100% abu batu	Berat jenis bulk (gsb) : 2,53083	Penetrasi : 60
	Berat jenis apparent :	Berat jenis (S) : 1,04

No. Benda Uji	Kadar Aspal		Berat Jenis		Berat (gram)			Volume bulk (cm³)	Berat jenis bulk (Gmb)	% Volume		% Pori			Stabilitas			Flow (mm)
	% Berat terhadap total agregat	% berat terhadap total campuran	Gse	Gmm	Di Udara	Dlm air	Kering Permukaan (ssd)			Aspal thdp campuran	Agregat efektif thdp campuran	VMA	VIM	VFA	Bacaan dial	Justifikasi (kg)	Koreksi Volume	
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	8.696	8	2.613	2.331	1069.3	575	1075.9	500.9	2.135	16.421	75.155	22.398	8.424	62.392	1550	1886.90	1836.465	5.21
2	8.696	8	2.613	2.331	1066.4	574	1071.1	497.1	2.145	16.502	75.524	22.017	7.974	63.783	2029	2460.71	1729.274	4.32
3	8.696	8	2.613	2.331	1063.5	578	1068.7	490.7	2.167	16.672	76.301	21.215	7.027	66.876	1552	1889.28	1769.310	4.87
1	9.290	8.5	2.613	2.315	1064.8	583	1070.1	487.1	2.186	17.866	76.541	20.967	5.593	73.326	1364	1665.87	1815.798	3.62
2	9.290	8.5	2.613	2.315	1075.5	582	1072.7	490.7	2.192	17.913	76.743	20.759	5.344	74.258	1402	1710.90	1864.881	3.79
3	9.290	8.5	2.613	2.315	1067.6	588	1078.6	490.6	2.176	17.786	76.195	21.325	6.020	71.771	1501	1828.57	1993.141	4.28
1	9.890	9	2.613	2.290	1061.6	590	1072.3	482.3	2.201	19.048	76.649	20.855	3.881	81.389	1380	1684.83	2056.721	3.28
2	9.890	9	2.613	2.290	1071.2	591	1079.5	488.5	2.193	18.976	76.361	21.153	4.243	79.941	1297	1586.49	2682.174	3.82
3	9.890	9	2.613	2.290	1067.6	597	1075.9	478.9	2.229	19.292	77.630	19.843	2.652	86.635	1328	1623.22	2059.315	4.12
1	10.497	9.5	2.613	2.285	1070.9	595	1082.1	487.1	2.199	20.083	76.138	21.383	3.779	82.326	1414	1725.11	1966.625	5.8
2	10.497	9.5	2.613	2.285	1066.6	598	1078.3	480.3	2.221	20.285	76.906	20.590	2.809	86.359	1402	1710.90	1950.426	4.91
3	10.497	9.5	2.613	2.285	1078.1	598	1081.4	483.4	2.230	20.372	77.237	20.249	2.391	88.193	1298	1587.67	1476.533	5.9
1	11.111	10	2.613	2.270	1065.9	592	1072.1	480.1	2.220	21.348	76.463	21.048	2.189	89.598	1259	1541.46	1757.264	6.61
2	11.111	10	2.613	2.270	1065.9	591	1066.9	475.9	2.240	21.536	77.138	20.351	1.326	93.483	1224	1500.00	1785.000	4.92
3	11.111	10	2.613	2.270	1066.3	598	1073.4	475.4	2.243	21.567	77.248	20.237	1.185	94.143	1155	1364.42	1623.660	5.57

Tabel L4.3 Hasil Pengujian Marshall untuk *Filler* Spen Katalis 25%

Tanggal :	Agregat	Aspal :
Jenis Campuran : 25% spen katalis + 75% abu batu	Berat jenis bulk (gsb) : 2,491	Penetrasi :60
	Berat jenis apparent : 2,665	Berat jenis (S) :1,042

No. Benda Uji	Kadar Aspal		Berat Jenis		Berat (gram)			Volume bulk (cm³)	Berat jenis bulk (Gmb)	% Volume		% Pori			Stabilitas			Flow (mm)
	% Berat terhadap total agregat	% berat terhadap total campuran	Gse	Gmm	Di Udara	Dlm air	Kering Permukaan (ssd)			Aspal thdp campuran	Agregat efektif thdp campuran	VMA	VIM	VFA	Bacaan dial	Justifikasi (kg)	Koreksi Volume	
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	8.696	8	2.585	2.311	1072.4	582	1079.0	497.0	2.158	16.598	76.807	20.321	6.627	67.390	1352	1651.65	1717.716	5.82
2	8.696	8	2.585	2.311	1081.6	584	1092.3	508.3	2.128	16.368	75.744	21.424	7.919	63.036	1428	1741.70	1811.368	5.77
3	8.696	8	2.585	2.311	1082.0	579	1081.3	502.3	2.154	16.570	76.677	20.456	6.785	66.832	1531	1864.28	1938.851	5.66
1	9.290	8.5	2.585	2.296	1077.2	583.0	1080.7	497.7	2.164	17.689	76.624	20.511	5.721	72.109	1420	1732.22	1801.509	4.86
2	9.290	8.5	2.585	2.296	1072.0	578.0	1075.3	497.3	2.156	17.618	76.315	20.831	6.100	70.715	1847	2243.96	2333.718	3.87
3	9.290	8.5	2.585	2.296	1082.8	585.0	1086.5	501.5	2.159	17.647	76.439	20.703	5.949	71.267	1519	1850.00	1924.000	4.52
1	9.890	9	2.585	2.281	1066.8	580.0	1070.6	490.6	2.174	18.818	76.562	20.576	4.657	77.367	1672	2032.60	2215.534	3.41
2	9.890	9	2.585	2.281	1067.3	586.0	1070.6	484.6	2.202	19.060	77.546	19.555	3.431	82.453	1571	1911.90	2083.971	3.61
3	9.890	9	2.585	2.281	1070.8	591.0	1073.4	482.4	2.220	19.209	78.155	18.923	2.673	85.876	1483	1807.14	2060.140	3.86
1	10.497	9.5	2.585	2.266	1058.4	587.0	1069.1	482.1	2.195	20.054	76.873	20.252	3.111	84.638	1711	2079.71	2370.869	5.61
2	10.497	9.5	2.585	2.266	1060.4	581.0	1060.4	479.4	2.212	20.205	77.452	19.652	2.381	87.882	1964	2383.33	2716.996	5.55
3	10.497	9.5	2.585	2.266	1059.1	584	1062.0	478.0	2.216	20.239	77.584	19.515	2.215	88.648	1712	2080.91	2372.237	4.82
1	11.111	10	2.585	2.251	1072.6	598	1082.1	484.1	2.216	21.304	77.154	19.961	1.582	92.073	1725	2096.61	2285.305	5.72
2	11.111	10	2.585	2.251	1086.6	599	1089.9	490.9	2.213	21.284	77.079	20.039	1.679	91.622	1672	2032.60	2215.534	5.81
3	11.111	10	2.585	2.251	1082.1	607	1096.4	489.4	2.211	21.260	76.995	20.126	1.786	91.127	1615	1964.28	2141.065	4.97

Tabel L4.4 Hasil Pengujian Marshall untuk *Filler* Spen Katalis 50% [Apriyadi, 2009]

Tanggal :	Agregat	Aspal :
Jenis Campuran : 50% spen katalis +50% abu batu	Berat jenis bulk (gsb) : 2,520844	Penetrasi : 60
	Berat jenis apparent :	Berat jenis (S) : 1,04

No. Benda Uji	Kadar Aspal		Berat Jenis		Berat (gram)			Volume bulk (cm³)	Berat jenis bulk (Gmb)	% Volume		% Pori			Stabilitas			Flow (mm)
	% Berat terhadap total agregat	% berat terhadap total campuran	Gse	Gmm	Di Udara	Dlm air	Kering Permukaan (ssd)			Aspal thdp campuran	Agregat efektif thdp campuran	VMA	VIM	VFA	Bacaan dial	Justifikasi (kg)	Koreksi Volume	
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	8.696	8	2.323	2.603	1070.7	577	1078.7	501.7	2.134	16.416	84.509	22.113	8.143	63.178	1441	1757.14	1827.426	5.22
2	8.696	8	2.323	2.603	1064.8	569	1070.9	501.9	2.122	16.320	84.010	22.573	8.685	61.524	1340	1637.44	1702.938	3.42
3	8.696	8	2.323	2.603	1059.8	567	1067.4	500.4	2.118	16.292	83.866	22.706	8.841	61.060	1370	1672.98	1739.899	5.26
1	9.290	8.5	2.308	2.603	1061.9	571.0	1068.2	497.2	2.136	17.456	84.677	22.478	7.456	66.827	1354	1654.02	1720.181	3.95
2	9.290	8.5	2.308	2.603	1096.4	590.0	1102.5	512.5	2.139	17.485	84.818	22.348	7.302	67.325	1503	1830.95	1830.950	3.11
3	9.290	8.5	2.308	2.603	1066.6	572.0	1070.9	498.9	2.138	17.473	84.762	22.400	7.364	67.126	1531	1864.28	1938.851	2.72
1	9.890	9	2.293	2.603	1066.7	579.0	1070.7	491.7	2.169	18.774	86.111	21.686	5.372	75.228	1764	2143.71	2229.458	3.72
2	9.890	9	2.293	2.603	1065.7	582.0	1070.5	488.5	2.182	18.879	86.594	21.247	4.842	77.213	1880	2283.33	2374.663	3.21
3	9.890	9	2.293	2.603	1071.1	578.0	1077.2	499.2	2.146	18.568	85.168	22.545	6.409	71.571	1582	1925.00	2002.000	3.85
1	10.497	9.5	2.277	2.603	1055.5	580.0	1059.7	479.7	2.200	20.099	87.434	21.007	3.388	83.871	1408	1718.00	1958.520	5.41
2	10.497	9.5	2.277	2.603	1067.9	587.0	1074.1	487.1	2.192	20.026	76.235	21.293	3.738	82.444	1105	1351.99	1473.669	4.3
3	10.497	9.5	2.277	2.603	1064.7	592	1069.5	477.5	2.230	20.368	77.535	19.951	2.097	89.489	1106	1353.23	1542.682	5.1
1	11.111	10	2.263	2.603	1071.4	587	1075.4	488.4	2.194	21.093	87.258	21.680	3.047	85.948	1347	1645.73	1793.846	5.72
2	11.111	10	2.263	2.603	1073.2	591	1075.1	484.1	2.217	21.316	76.663	20.852	2.021	90.308	1392	1699.05	1936.917	5.65
3	11.111	10	2.263	2.603	1072.1	581	1074.1	493.1	2.174	20.906	75.186	22.376	3.908	82.535	1324	1618.48	1845.067	4.45

Tabel L4.5 Hasil Pengujian Marshall untuk *Filler* Spen Katalis 75%

Tanggal :	Agregat	Aspal
Jenis Campuran : 75% spen katalis + 25% abu batu	Berat jenis bulk (gsb) : 2,480	Penetrasi : 60
	Berat jenis apparent : 2,663	Berat jenis (S) : 1,042

No. Benda Uji	Kadar Aspal		Berat Jenis		Berat (gram)			Volume bulk (cm³)	Berat jenis bulk (Gmb)	% Volume		% Pori			Stabilitas			Flow (mm)
	% Berat terhadap total agregat	% berat terhadap total campuran	Gse	Gmm	Di Udara	Dlm air	Kering Permukaan (ssd)			Aspal thdp campuran	Agregat efektif thdp campuran	VMA	VIM	VFA	Bacaan dial	Justifikasi (kg)	Koreksi Volume	
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	8.696	8	2.572	2.302	1064.4	574	1078.0	504.0	2.112	16.245	75.543	21.646	8.243	61.920	1135	1389.3	1430.979	4.98
2	8.696	8	2.572	2.302	1072.0	579	1086.3	507.3	2.113	16.255	75.587	21.600	8.189	62.089	1118	1368.15	1422.876	4.61
3	8.696	8	2.572	2.302	1069.9	572	1072.2	500.2	2.139	16.453	76.510	20.643	7.068	65.761	1108	1355.72	1396.392	5.12
1	9.290	8.5	2.572	2.287	1059.2	569	1062.4	493.4	2.147	17.545	76.372	20.787	6.117	70.574	1245	1524.88	1662.119	3.81
2	9.290	8.5	2.572	2.287	1059.7	562	1062.1	500.1	2.119	17.319	75.384	21.811	7.331	66.390	1367	1669.43	1819.679	4.41
3	9.290	8.5	2.572	2.287	1061.1	562	1065.3	503.3	2.108	17.231	75.004	22.206	7.798	64.881	1312	1604.26	1748.643	3.25
1	9.890	9	2.572	2.272	1069.1	572	1069.1	497.1	2.151	18.612	76.094	21.075	5.331	74.707	1472	1794.04	1955.504	4.64
2	9.890	9	2.572	2.272	1066.1	578	1066.1	488.1	2.184	18.902	77.279	19.845	3.856	80.572	1465	1785.71	1946.424	4.36
3	9.890	9	2.572	2.272	1066.7	571	1066.3	495.3	2.154	18.637	76.199	20.966	5.200	75.199	1642	1996.42	2176.098	4.24
1	10.497	9.5	2.572	2.257	1062.1	574	1067.0	493.0	2.154	19.679	75.805	21.374	4.553	78.697	1446	1763.09	1921.768	4.5
2	10.497	9.5	2.572	2.257	1063.3	581	1067.4	486.4	2.186	19.969	76.921	20.217	3.149	84.425	1438	1753.57	1911.391	4.38
3	10.497	9.5	2.572	2.257	1064.6	577	1067.8	490.8	2.169	19.814	76.324	20.836	3.900	81.283	1266	1549.76	1689.238	4.6
1	11.111	10	2.572	2.243	1082.1	589	1086.6	497.6	2.175	20.910	76.096	21.073	3.034	85.601	1151	1409.20	1536.028	4.67
2	11.111	10	2.572	2.243	1092.1	593	1088.7	495.7	2.203	21.184	77.093	20.038	1.763	91.201	1221	1496.26	1630.923	5.37
3	11.111	10	2.572	2.243	1086.9	582	1077.9	495.9	2.192	21.075	76.695	20.451	2.270	88.899	1231	1508.29	1644.036	5.31

Tabel L4.6 Hasil Pengujian Marshall untuk *Filler* Spen Katalis 100% [Apriyadi, 2009]

Tanggal :	Agregat	Aspal :
Jenis Campuran : 100% spen katalis	Berat jenis bulk (gsb) : 2.5109371	Penetrasi : 60
	Berat jenis apparent :	Berat jenis (S) : 1,04

No. Benda Uji	Kadar Aspal		Berat Jenis		Berat (gram)			Volume bulk (cm^3)	Berat jenis bulk (Gmb)	% Volume		% Pori			Stabilitas			Flow (mm)
	% Berat terhadap total agregat	% berat terhadap total campuran	Gse	Gmm	Di Udara	Dlm air	Kering Permukaan (ssd)			Aspal thdp campuran	Agregat efektif thdp campuran	VMA	VIM	VFA	Bacaan dial	Justifikasi (kg)	Koreksi Volume	
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	8.700	8	2.316	2.592	1058.7	554	1065.3	511.3	2.071	15.928	73.493	24.134	10.579	56.164	1545	1880.95	1880.950	3.23
2	8.700	8	2.316	2.592	1061.0	560	1067.3	507.3	2.091	16.088	74.233	23.369	9.678	58.585	1459	1778.57	1849.713	3.82
3	8.700	8	2.316	2.592	1068.5	564	1073.7	509.7	2.096	16.126	74.406	23.191	9.468	59.173	1460	1779.76	1779.760	3.99
1	9.290	8.5	2.300	2.592	1057.2	567.0	1064.3	497.3	2.126	17.375	75.045	22.532	7.580	66.358	1660	2018.11	2098.834	3.54
2	9.290	8.5	2.300	2.592	1055.6	562.0	1062.1	500.1	2.111	17.252	74.512	23.082	8.237	64.316	1667	2026.57	2107.633	3.3
3	9.290	8.5	2.300	2.592	1059.6	565.0	1065.8	500.8	2.116	17.293	74.690	22.898	8.018	64.986	1594	1939.28	2016.851	3.15
1	9.890	9	2.285	2.592	1077.9	575.0	1080.2	505.2	2.134	18.464	74.906	22.675	6.630	70.761	1750	2126.81	2211.882	4.6
2	9.890	9	2.285	2.592	1078.0	576.0	1083.5	507.5	2.124	18.382	74.574	23.018	7.044	69.396	1780	2163.04	2249.562	3.82
3	9.890	9	2.285	2.592	1069.3	579.0	1074.8	495.8	2.157	18.664	75.717	21.837	5.619	74.270	1910	2319.04	2411.802	4.54
1	10.497	9.5	2.270	2.592	1057.5	565.0	1062.6	497.6	2.125	19.413	74.201	23.403	6.386	72.712	1281	1567.53	1630.231	4.98
2	10.497	9.5	2.270	2.592	1071.4	579.0	1076.4	497.4	2.154	19.676	75.207	22.365	5.117	77.118	1322	1616.11	1680.754	4.56
3	10.497	9.5	2.270	2.592	1070.2	582	1077.4	495.4	2.160	19.733	75.426	22.139	4.841	78.133	1265	1548.57	1687.941	3.48
1	11.111	10	2.255	2.592	1060.1	575	1065.3	490.3	2.162	20.790	75.074	22.502	4.136	81.618	1424	1736.96	1893.286	5.15
2	11.111	10	2.255	2.592	1069.7	582	1075.6	493.6	2.167	20.838	75.247	22.323	3.915	82.463	1180	1445.27	1575.344	4.73
3	11.111	10	2.255	2.592	1071.2	585	1076.8	491.8	2.178	20.943	75.629	21.929	3.428	84.368	1108	1355.72	1477.735	4.56

LAMPIRAN V
PERHITUNGAN PENGUJIAN MARSHALL

L6.1 Contoh Perhitungan Uji Marshall untuk *Filler* 100% Abu Batu

Pada contoh ini menggunakan nomor benda uji 1 dengan kadar aspal 8,5%.

(A) % Berat kadar aspal terhadap total agregat

$$(A) = \frac{B}{(100 - B)} \text{ x } 100\%$$

$$= \frac{8,5}{(100 - 8,5)} \text{ x } 100\%$$

$$= 9,290$$

(B) % Berat kadar aspal terhadap total campuran = 8,5%

(C) Berat jenis efektif agregat (G_{se})

$$G_{se} = \frac{\% \text{ Agregat kasar} + \% \text{ Agregat halus} + \% \textit{ filler}}{\frac{\% \text{ Agregat kasar}}{\text{BJ Agregat kasar}} + \frac{\% \text{ Agregat halus}}{\text{BJ Agregat halus}} + \frac{\% \textit{ filler}}{\text{BJ } \textit{filler}}}$$

$$G_{se} = \frac{5 + 15 + 10 + 9 + 7 + 4 + 7 + 6 + 14 + 14 + 9}{\frac{5}{2,622} + \frac{15}{2,654} + \frac{10}{2,616} + \frac{9}{2,621} + \frac{7}{2,593} + \frac{4}{2,616} + \frac{7}{2,643} + \frac{6}{2,591} + \frac{14}{2,539} + \frac{14}{2,524} + \frac{9}{2,551}} = 2,591$$

(D) Berat jenis campuran beton yang belum dipadatkan (G_{mm})

$$G_{mm} = \frac{100}{\frac{\% \text{ Agregat}}{G_{se}} + \frac{\% \text{ Aspal}}{\text{BJ Aspal}}}$$

$$G_{mm} = \frac{100}{\frac{91,5}{2,591} + \frac{8,5}{1,042}} = 2,300$$

(E) Berat benda uji di udara = 1054,7 gram

(F) Berat benda uji dalam air = 573 gram

(G) Berat benda uji kering permukaan = 1059,8 gram.

(H) Volume Bulk

(H) = Berat kering permukaan – Berat dalam air

= 1059,8 - 573

= 486,8 cm³

(I) Berat Jenis Bulk (G_{mb})

$$(I) = \frac{\text{Berat di udara}}{\text{Volume bulk}}$$

$$= \frac{1054,7}{486,8}$$

= 2,167

(J) %Volume aspal terhadap campuran

$$(J) = \frac{(B) \text{ x } (I)}{\text{BJ aspal}}$$

$$= \frac{(8,5 \times 2,167)}{1,042}$$

= 17,708%

(K) % Volume agregat efektif terhadap campuran

$$(K) = \frac{(I) \text{ x } (100 - B)}{(C)}$$

$$= \frac{(2,167\,(100 - 8,5))}{2,591}$$

= 76,516%

(L) Persentase pori antar butir campuran agregat (VMA)

$$(L) = 100 - \frac{((100 - B) \text{ x } I)}{G_{sb}}$$

$$= 100 - \frac{((100 - 8,5) \text{ x } 2,167)}{2,497}$$

= 20,616%

(M) Persentase pori benda uji (VIM)

$$(M) = \frac{100 \text{ x } (D - I)}{(D)}$$

$$= \frac{100 \text{ x } (2{,}300 - 2{,}167)}{2{,}300}$$

= 5,810%

(N) Persentase pori antar butir campuran agregat yang terisi aspal (VFA)

$$(N) = \frac{100. \text{ x } (L - M)}{(L)}$$

$$= \frac{100 \text{ x } (20{,}616 - 5{,}810)}{20{,}616}$$

= 71,816 %

(O) Bacaan dial (arloji stabilitas) = 1352

(P) Justifikasi stabilitas = 1651,65 kg

(Q) Koreksi volume stabilitas

(Q) = (P) x Angka korelasi stabilitas

= 1651,65 x 1,09

= 1800,299 kg

(R) *Flow* = 5,84

L6.2 Contoh Perhitungan Uji Marshall untuk *Filler* 25% Spen Katalis + 75% Abu Batu

Pada contoh ini menggunakan nomor benda uji 1 dengan kadar aspal 9%.

(A) % Berat terhadap total agregat

$$(A) = \frac{B}{(100 - B)} \text{ x } 100\%$$

$$= \frac{9}{(100 - 9)} \text{ x } 100\%$$

$$= 9{,}890$$

(B) % Berat total terhadap total campuran = 9%

(C) Berat jenis efektif agregat (G_{se})

$$G_{se} = \frac{\%\text{ Agregat kasar} + \%\text{ Agregat halus} + \%\ \textit{filler}}{\dfrac{\%\text{ Agregat kasar}}{\text{BJ Agregat kasar}} + \dfrac{\%\text{ Agregat halus}}{\text{BJ Agregat halus}} + \dfrac{\%\ \textit{filler}}{\text{BJ }\textit{filler}}}$$

$$G_{se} = \frac{5+15+10+9+7+4+7+6+14+14+2{,}25+6{,}75}{\frac{5}{2{,}622}+\frac{15}{2{,}654}+\frac{10}{2{,}616}+\frac{9}{2{,}621}+\frac{7}{2{,}593}+\frac{4}{2{,}616}+\frac{7}{2{,}643}+\frac{6}{2{,}591}+\frac{14}{2{,}539}+\frac{14}{2{,}524}+\frac{2{,}25}{2{,}304}+\frac{6{,}75}{2{,}551}} = 2{,}585$$

(D) Berat jenis campuran beton yang belum dipadatkan (G_{mm})

$$G_{mm} = \frac{100}{\dfrac{\%\text{ Agregat}}{G_{se}} + \dfrac{\%\text{ Aspal}}{\text{BJ Aspal}}}$$

$$G_{mm} = \frac{100}{\dfrac{91}{2{,}585} + \dfrac{9}{1{,}042}} = 2{,}281$$

(E) Berat benda uji di udara = 1066,8 gram

(F) Berat benda uji dalam air = 580 gram

(G) Berat benda uji kering permukaan = 1070,6 gram.

(H) Volume Bulk

(H) = Berat kering permukaan – Berat dalam air

= 1070,6 - 580

= 490,6 cm³

(I) Berat Jenis Bulk (G_{mb})

$$(I) = \frac{\text{Berat di udara}}{\text{Volume bulk}}$$

$$= \frac{1066,8}{490,6}$$

= 2,174

(J) %Volume aspal terhadap campuran

$$(J) = \frac{(B) \text{ x } (I)}{\text{BJ aspal}}$$

$$= \frac{(9 \times 2,174)}{1,042}$$

= 18,818%

(K) % Volume agregat efektif terhadap campuran

$$(K) = \frac{(I) \text{ x } (100 - B)}{(C)}$$

$$= \frac{(2,174\,(100 - 9))}{2,585}$$

= 76,562%

(L) Persentase pori antar butir campuran agregat (VMA)

$$(L) = 100 - \frac{((100 - B) \text{ x } I)}{G_{sb}}$$

$$= 100 - \frac{((100 - 9) \text{ x } 2,174)}{2,497}$$

= 20,576%

(M) Persentase pori benda uji (VIM)

$$(M) = \frac{100 \text{ x } (D - I)}{(D)}$$

$$(M) = \frac{100 \text{ x } (2{,}281 - 2{,}174)}{2{,}281}$$

$$= 4{,}657\%$$

(N) Presentase pori antar butir campuran agregat yang terisi aspal (VFA)

$$(N) = \frac{100. \text{ x } (L - M)}{(L)}$$

$$= \frac{100 \text{ x } (20{,}576 - 4{,}657)}{20{,}576}$$

$$= 77{,}367\ \%$$

(O) Bacaan dial (arloji stabilitas) = 1672

(P) Justifikasi stabilitas = 2032,60 kg

(Q) Koreksi volume stabilitas

(Q) = (P) x Angka korelasi stabilitas

= 2032,60 x 1,09

= 2215,534 kg

(R) *Flow* = 3,41

L6.3 Contoh Perhitungan Uji Marshall untuk *Filler* 75% Spen Katalis + 25% Abu Batu

Pada contoh ini menggunakan nomor benda uji 1 dengan kadar aspal 10%.

(A) % Berat terhadap total agregat

$$(A) = \frac{B}{(100 - B)} \text{ x } 100\%$$

$$= \frac{10}{(100 - 10)} \text{ x } 100\%$$

$$= 9{,}890$$

(B) % Berat total terhadap total campuran = 10%

(C) Berat jenis efektif agregat (G_{se})

$$G_{se} = \frac{\%\text{ Agregat kasar} + \%\text{ Agregat halus} + \%\ \textit{filler}}{\dfrac{\%\text{ Agregat kasar}}{\text{BJ Agregat kasar}} + \dfrac{\%\text{ Agregat halus}}{\text{BJ Agregat halus}} + \dfrac{\%\ \textit{filler}}{\text{BJ }\textit{filler}}}$$

$$G_{se} = \frac{5+15+10+9+7+4+7+6+14+14+2{,}25+6{,}75}{\frac{5}{2{,}622}+\frac{15}{2{,}654}+\frac{10}{2{,}616}+\frac{9}{2{,}621}+\frac{7}{2{,}593}+\frac{4}{2{,}616}+\frac{7}{2{,}643}+\frac{6}{2{,}591}+\frac{14}{2{,}539}+\frac{14}{2{,}524}+\frac{6{,}75}{2{,}304}+\frac{2{,}25}{2{,}551}} = 2{,}572$$

(D) Berat jenis campuran beton yang belum dipadatkan (G_{mm})

$$G_{mm} = \frac{100}{\dfrac{\%\text{ Agregat}}{G_{se}} + \dfrac{\%\text{ Aspal}}{\text{BJ Aspal}}}$$

$$G_{mm} = \frac{100}{\dfrac{90}{2{,}572} + \dfrac{10}{1{,}042}} = 2{,}243$$

(E) Berat benda uji di udara = 1082,1 gram

(F) Berat benda uji dalam air = 589 gram

(G) Berat benda uji kering permukaan = 1086,6 gram.

(H) Volume Bulk

(H) = Berat kering permukaan – Berat dalam air

= 1086,6 - 589

= 497,6 cm³

(I) Berat Jenis Bulk (G_{mb})

$$(I) = \frac{\text{Berat di udara}}{\text{Volume bulk}}$$

$$= \frac{1082,1}{497,6}$$

= 2,175

(J) %Volume aspal terhadap campuran

$$(J) = \frac{(B) \text{ x } (I)}{\text{BJ aspal}}$$

$$= \frac{(9 \times 2,175)}{1,042}$$

= 20,910%

(K) % Volume agregat efektif terhadap campuran

$$(K) = \frac{(I) \text{ x } (100 - B)}{(C)}$$

$$= \frac{(2,175\,(100 - 10))}{2,572}$$

= 76,096%

(L) Persentase pori antar butir campuran agregat (VMA)

$$(L) = 100 - \frac{((100 - B) \text{ x } I)}{G_{sb}}$$

$$= 100 - \frac{((100 - 10) \text{ x } 2,175)}{2,480}$$

= 21,073%

(M) Persentase pori benda uji (VIM)

$$(M) = \frac{100 \text{ x } (D - I)}{(D)}$$

$$(M) = \frac{100 \text{ x } (2{,}243 - 2{,}175)}{2{,}243}$$

= 3,034%

(N) Presentase pori antar butir campuran agregat yang terisi aspal (VFA)

$$(N) = \frac{100. \text{ x } (L - M)}{(L)}$$

$$= \frac{100 \text{ x } (21{,}073 - 3{,}034)}{21{,}073}$$

= 85,061 %

(O) Bacaan dial (arloji stabilitas) = 1151

(P) Justifikasi stabilitas = 1409,20 kg

(Q) Koreksi volume stabilitas

(Q) = (P) x Angka korelasi stabilitas

= 1409,20 x 1,09

= 1536,028 kg

(R) *Flow* = 4,67

LAMPIRAN VI

ANGKA KORELASI STABILITAS

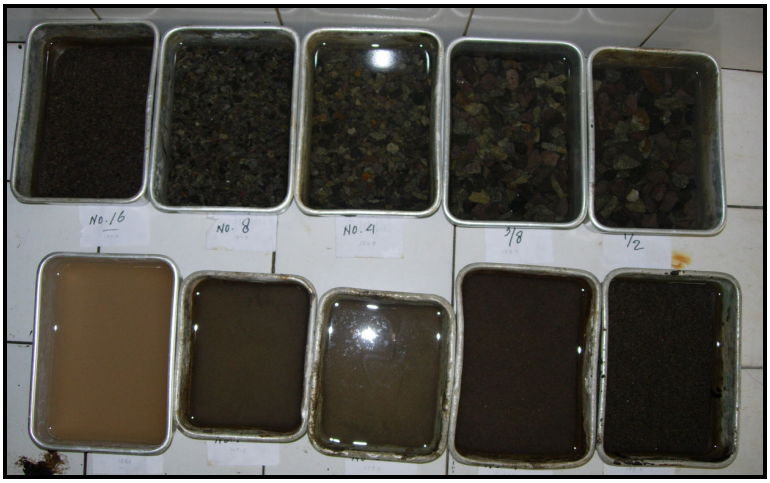
Tabel L6.1 Angka Korelasi Stabilitas

Isi Benda Uji (cm^3)	Tebal Benda Uji		Angka Korelasi
	inci	mm	
200 – 213	1	25,4	5,56
214 – 225	1 $^{1}/_{16}$	27,0	5,00
226 – 237	1 $^{1}/_{8}$	28,6	4,55
238 – 250	1 $^{3}/_{16}$	30,2	4,17
251 – 264	1 ¼	31,8	3,85
265 – 276	1 $^{5}/_{16}$	33,3	3,57
277 – 289	1 $^{3}/_{8}$	34,9	3,33
290 – 301	1 $^{7}/_{16}$	36,5	3,03
302 – 316	1 ½	38,1	2,78
317 – 328	1 $^{9}/_{16}$	39,7	2,50
329 – 340	1 $^{5}/_{8}$	41,3	2,27
341 – 353	1 $^{11}/_{16}$	42,9	2,08
354 – 367	1 ¾	44,4	1,92
368 – 379	1 $^{13}/_{16}$	46,0	1,79
380 – 392	1 $^{7}/_{8}$	47,6	1,67
393 – 405	1 $^{15}/_{16}$	49,2	1,56
406 – 420	2	50,8	1,47
421 – 431	2 $^{1}/_{16}$	52,4	1,39
432 – 443	2 $^{1}/_{8}$	54,0	1,32
444 – 456	2 $^{3}/_{16}$	55,6	1,25
457 – 470	2 ¼	57,2	1,19
471 – 482	2 $^{5}/_{16}$	58,7	1,14
483 – 495	2 $^{3}/_{8}$	60,3	1,09
496 – 508	2 $^{7}/_{16}$	61,9	1,04
509 – 522	2 ½	63,5	1,00
523 – 535	2 $^{9}/_{16}$	64,0	0,96
536 – 546	2 $^{5}/_{8}$	65,1	0,93
547 – 559	2 $^{11}/_{16}$	66,7	0,89
560 – 573	2 ¾	68,3	0,86
574 – 585	2 $^{13}/_{16}$	71,4	0,83
586 – 598	2 $^{7}/_{8}$	73,0	0,81
599 – 610	2 $^{15}/_{16}$	74,6	0,78
611 - 625	3	76,2	0,76

LAMPIRAN VII

FOTO-FOTO PENELITIAN DI LABORATORIUM

Gambar L7.1 Susunan Ukuran Saringan



Gambar L7.2 Pemeriksaan Agregat

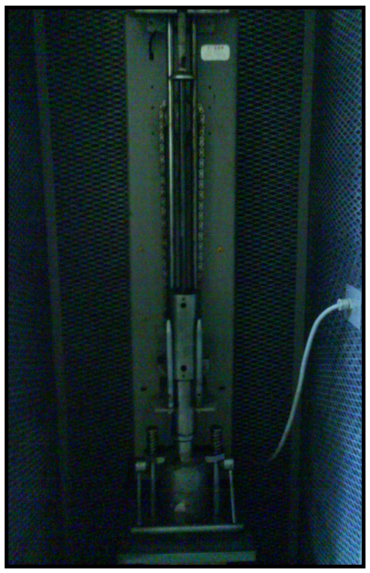
Gambar L7.3 Alat Pengujian Penetrasi Aspal

Gambar L7.4 Pengujian Daktilitas

Gambar L7.5 Pencampuran Agregat dan Aspal

Gambar L7.6 Pemanasan Benda Uji

Gambar L7.7 Campuran dalam *Mold*

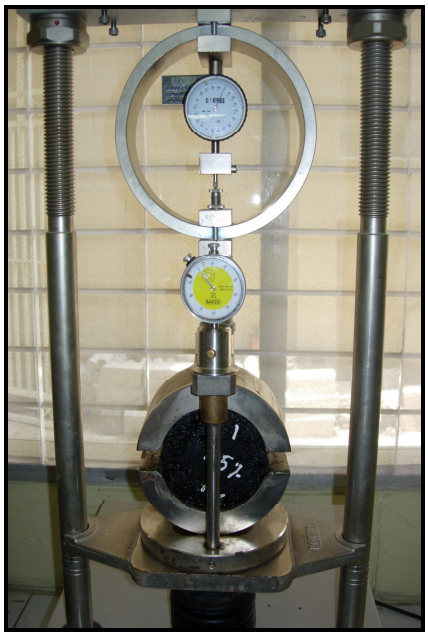


Gambar L7.8 Alat Penumbuk Otomatis *(Compactor)*

Gambar L7.9 Benda Uji dengan *filler* 100% Abu Batu (Kadar Aspal 8,5%)

Gambar L7.10 Alat Dongkrak

Gambar L7.11 Benda Uji dalam *Waterbath*



Gambar L7.12 Pengujian Marshall