

LAMPIRAN

I

Pemeriksaan Gradasi Abu Batu

1. Berat cawan kosong = 215 gram
2. Berat pasir SSD = 1000 gram
3. Berat pasir + cawan = 1215 gram

Tabel 1. Hasil Analisis Gradasi Abu batu

No. Saringan	Berat tertahan (gram)	Berat tertahan (%)	Berat Tertahan Kumulatif (%)	Berat lolos Kumulatif (%)
4 (4,75 mm)	0	0	0	100
8 (2,36 mm)	85	8,5	8,5	91,5
16 (1,18 mm)	202	20,2	28,7	71,3
30 (0,6mm)	189	18,9	47,6	52,4
50 (0,3mm)	140	14	61,6	38,4
100 (0,15mm)	232	23,2	84,8	15,2
Pan	152	15,2	100	0
Total	1000	100	331,2	Daerah 2 (abu batu agak kasar)

$$\begin{aligned}
 \text{Modulus Halus Butir (MHB)} &= \frac{\text{jumlah berat tertahan kumulatif (\%)}}{\text{jumlah berat tertahan (\%)}} \\
 &= \frac{331,2}{100} \\
 &= 3,312 \%
 \end{aligned}$$

Pemeriksaan Kadar Air Agregat Halus (Abu Batu)

Tabel 2. Hasil Analisis Kadar Air Agregat Halus (Abu Batu)

Uraian	Sampel 1	Sampel 2
Berat Wadah (W1)	130 gr	134 gr
Berat Wadah + Contoh Basah (W2)	630 gr	634 gr
Berat Wadah + Contoh kering (W3)	620 gr	616 gr
Berat air (W4 = W2-W3)	18 gr	18 gr
Berat Contoh Kering (W5=W3-W1)	490 gr	482 gr
Kadar air (W4/W5) x 100%	2,04 %	3,75 %
Kadar air rata rata	2,94 %	

a. Kandungan air

$$\begin{aligned}
 &= W2 - W3 \\
 &= 630 - 620 \\
 &= 10 \text{ gram}
 \end{aligned}$$

b. Berat Contoh kering

$$\begin{aligned}
 &= W3 - W1 \\
 &= 620 - 130 \\
 &= 490 \text{ gr}
 \end{aligned}$$

c. Kadar air

$$\begin{aligned}
 &= \frac{\text{Kandungan air}(W4)}{\text{berat kering}(W5)} \times 100\% \\
 &= \frac{18}{490} \times 100\% \\
 &= 2,04 \%
 \end{aligned}$$

d. Rata-Rata

$$= \frac{2,04\% + 3,75\%}{2} = 2,94 \%$$

Pemeriksaan Kadar Air Agregat Kasar I

Tabel 2. Hasil Analisis Kadar Air Agregat Kasar I

Uraian	Sampel 1	Sampel 2
Berat Wadah (W1)	198 gr	135 gr
Berat Wadah + Contoh Basah (W2)	1198 gr	1135 gr
Berat Wadah + Contoh kering (W3)	1190 gr	1131 gr
Berat air (W4 = W2-W3)	8 gr	4 gr
Berat Contoh Kering (W5=W3-W1)	992 gr	996 gr
Kadar air (W4/W5) x 100%	0,806 %	0,401 %
Kadar air rata rata	0,6035 %	

a. Kandungan air

$$\begin{aligned}
 &= W2 - W3 \\
 &= 1198 - 1190 \\
 &= 8 \text{ gram}
 \end{aligned}$$

b. Berat Contoh kering

$$\begin{aligned}
 &= W3 - W1 \\
 &= 1190 - 198 \\
 &= 992 \text{ gr}
 \end{aligned}$$

c. Kadar air

$$\begin{aligned}
 &= \frac{\text{Kandungan air}(W4)}{\text{berat kering}(W5)} \times 100\% \\
 &= \frac{8}{992} \times 100\% \\
 &= 0,806 \%
 \end{aligned}$$

d. Rata-Rata

$$= \frac{0,806\% + 0,401\%}{2} = 0,6035 \%$$

Pemeriksaan Kadar Air Agregat Kasar II

Tabel 2. Hasil Analisis Kadar Air Agregat Kasar II

Uraian	Sampel 1	Sampel 2
Berat Wadah (W1)	121,64 gr	285,74 gr
Berat Wadah + Contoh Basah (W2)	1121,64 gr	1285,74 gr
Berat Wadah + Contoh kering (W3)	1112 gr	1268 gr
Berat air (W4 = W2-W3)	9,64 gr	17,74 gr
Berat Contoh Kering (W5=W3-W1)	990,36 gr	982,26 gr
Kadar air (W4/W5) x 100%	0,97 %	1,806 %
Kadar air rata rata	1,388 %	

a. Kandungan air

$$\begin{aligned}
 &= W2 - W3 \\
 &= 1121,64 - 1112 \\
 &= 9,64 \text{ gram}
 \end{aligned}$$

b. Berat Contoh kering

$$\begin{aligned}
 &= W3 - W1 \\
 &= 1112 - 121,64 \\
 &= 990,36 \text{ gr}
 \end{aligned}$$

c. Kadar air

$$\begin{aligned}
 &= \frac{\text{Kandungan air}(W4)}{\text{berat kering}(W5)} \times 100\% \\
 &= \frac{9,64}{990,36} \times 100\% \\
 &= 0,97\%
 \end{aligned}$$

d. Rata-Rata

$$= \frac{0,97\% + 1,806\%}{2} = 1,388\%$$

Pemeriksaan Berat Jenis dan Penyerapan Air Agregat Halus (Abu Batu)

Tabel 3, Hasil Analisis Berat Jenis Agregat Halus (Abu Batu)

Uraian	Berat	
	Berat piknometer berisi pasir dan air (B_t)	1026 gr
Berat pasir setelah kering (B_k)	500 gr	500 gr
Berat piknometer berisi air (B)	726 gr	775 gr
Berat pasir keadaan jenuh kering muka (SSD)	519 gr	514 gr

a, Berat jenis curah (*bulk specific gravity*)

$$= \frac{B_k}{B + SSD - B_t} = \frac{500}{726 + 519 - 1026} = 2,28$$

b, Berat jenis jenuh kering muka (*saturated surface dry*)

$$= \frac{SSD}{B + SSD - B_t} = \frac{519}{726 + 519 - 1026} = 2,37$$

c, Berat jenis tampak (*apparent specific gravity*)

$$= \frac{B_k}{B + B_k - B_t} = \frac{500}{726 + 500 - 1026} = 2,5$$

d, Penyerapan air agregat halus (Abu Batu)

$$= \frac{SSD - B_k}{B_k} \times 100\% = \frac{519 - 500}{500} \times 100\% = 3,8\%$$

e, Berat jenis jenuh kering muka rata-rata

$$= \frac{SSD1 + SSD2}{2} = \frac{2,37 + 2,35}{2} = 2,36$$

Pemeriksaan Berat Jenis dan Penyerapan Air Agregat Kasar I

Tabel 4, Hasil Analisis Berat Jenis Agregat Kasar I

Uraian	Berat
Berat Batu Muda setelah kering (B_k)	5000 gr
Berat piknometer berisi air (B_a)	3020 gr
Berat Batu Muda keadaan jenuh kering muka (B_j)	5014 gr

a, Berat jenis curah (*bulk specific gravity*)

$$= \frac{B_k}{B_j - B_a} = \frac{5000}{5014 - 3020} = 2,507$$

b, Berat jenis jenuh kering muka (*saturated surface dry*)

$$= \frac{B_j}{B_j - B_a} = \frac{5014}{5014 - 3020} = 2,514$$

c, Berat jenis tampak (*apparent specific gravity*)

$$= \frac{B_k}{B_k - B_a} = \frac{5000}{5000 - 3020} = 2,52$$

d, Penyerapan air agregat kasar (Batu Muda)

$$= \frac{B_j - B_k}{B_k} \times 100\% = \frac{5014 - 5000}{5000} \times 100\% = 0,28\%$$

Pemeriksaan Berat Jenis dan Penyerapan Air Agregat Kasar II

Tabel 4, Hasil Analisis Berat Jenis Agregat Kasar II

Uraian	Berat
Berat Batu Tua setelah kering (B_k)	4900,76 gr
Berat piknometer berisi air (B_a)	3125 gr
Berat Batu Tua keadaan jenuh kering muka (B_j)	5021,77 gr

a, Berat jenis curah (*bulk specific gravity*)

$$= \frac{B_k}{B_j - B_a} = \frac{4900,76}{5021,77 - 3125} = 2,58$$

b, Berat jenis jenuh kering muka (*saturated surface dry*)

$$= \frac{B_j}{B_j - B_a} = \frac{5021,77}{5021,77 - 3125} = 2,65$$

c, Berat jenis tampak (*apparent specific gravity*)

$$= \frac{B_k}{B_k - B_a} = \frac{4900,76}{4900,76 - 3125} = 2,76$$

d, Penyerapan air agregat kasar (Batu Tua).

$$= \frac{B_j - B_k}{B_k} \times 100\% = \frac{5021,77 - 4900,76}{4900,76} \times 100\% = 2,47\%$$

Pemeriksaan Berat Satuan Agregat Halus (Abu Batu)

a. Berat satuan

- bejana : d = 15,13 cm
 h = 30,00 cm
- berat bejana kosong (B₁) = 10800 gram
- berat bejana berisi pasir SSD (B₂) = 20200 gram
- volume bejana kosong (V) = $\frac{1}{4} \times \pi \times d^2 \times h$
 = $\frac{1}{4} \times \pi \times (15,13^2) \times 30,00$
 = 5393,7274 cm³

$$\begin{aligned} \text{Berat satuan} &= \frac{B_2 - B_1}{v} \\ &= \frac{20200 - 10800}{5393,7274} \\ &= 1,743 \text{ gr/cm}^3 \end{aligned}$$

Pemeriksaan Berat Satuan Agregat Kasar I

a. Berat satuan

- bejana : d = 15,13 cm
 h = 30,00 cm
- berat bejana kosong (B_1) = 10800 gram
- berat bejana berisi pasir SSD (B_2) = 18400 gram
- volume bejana kosong (V) = $1/4 \times \pi \times d^2 \times h$
 = $1/4 \times \pi \times (15,13^2) \times 30,00$
 = 5393,7274 cm³

$$\begin{aligned} \text{Berat satuan} &= \frac{B_2 - B_1}{v} \\ &= \frac{18400 - 10800}{5393,7274} \\ &= 1,489 \text{ gr/cm}^3 \end{aligned}$$

Pemeriksaan Berat Satuan Agregat Kasar II

a. Berat satuan

- bejana : d = 15 cm
 h = 29,4 cm
- berat bejana kosong (B₁) = 10700 gram
- berat bejana berisi pasir SSD (B₂) = 19000 gram
- volume bejana kosong (V) = $\frac{1}{4} \times \pi \times d^2 \times h$
 = $\frac{1}{4} \times \pi \times (15^2) \times 29,4$
 = 5195,41 cm³

$$\begin{aligned} \text{Berat satuan} &= \frac{B_2 - B_1}{v} \\ &= \frac{19000 - 10700}{5195,41} \\ &= 1,6 \text{ gr/cm}^3 \end{aligned}$$

Pemeriksaan Keausan Agregat Kasar Agregat Kasar I

Tabel 5, Hasil Analisis Berat Jenis Agregat Kasar (Batu Muda)

Jenis Pengukuran	Berat
Berat sebelum masuk mesin <i>Los Angeles</i> (B ₁)	5000 gr
Berat setelah masuk mesin <i>Los Angeles</i> (B ₂)	2042 gr
Keausan = $\frac{B_1 - B_2}{B_1} \times 100\%$	40,48 %

A. Analisis hitungan

$$\begin{aligned}
 1. \quad \text{Keausan agregat kasar contoh 1} &= \frac{B_1 - B_2}{B_1} \times 100\% \\
 &= \frac{5000 - 2042}{5000} \times 100\% \\
 &= 40,48 \%
 \end{aligned}$$

Pemeriksaan Keausan Agregat Kasar Agregat Kasar II

Tabel 5, Hasil Analisis Berat Jenis Agregat Kasar (Batu Tua)

Jenis Pengukuran	Berat
Berat sebelum masuk mesin <i>Los Angeles</i> (B ₁)	5000 gr
Berat setelah masuk mesin <i>Los Angeles</i> (B ₂)	4325 gr
Keausan = $\frac{B_1 - B_2}{B_1} \times 100\%$	13,5 %

B. Analisis hitungan

$$\begin{aligned}
 2. \quad \text{Keausan agregat kasar contoh 1} &= \frac{B_1 - B_2}{B_1} \times 100\% \\
 &= \frac{5000 - 4325}{5000} \times 100\% \\
 &= 13,5 \%
 \end{aligned}$$

Pemeriksaan Kadar Lumpur Agregat Halus (Abu Batu)

Tabel 4. Hasil Analisis Kadar Lumpur Agregat Halus (Abu Batu)

Uraian	Berat	
	Pasir jenuh kering muka (SSD) (B_1)	1000 gr
Pasir setelah keluar oven (B_2)	932 gr	928 gr
Kandungan air ($B_1 - B_2$)	68 gr	72 gr
$Kadar\ lumpur = \frac{B_1 - B_2}{B_1} \times 100\%$	6,8 %	7,2 %

a. Kandungan air = $B_1 - B_2$
 = 1000 - 932
 = 68 gram

b. Kadar Lumpur = $\frac{B_1 - B_2}{B_1} \times 100\%$
 = $\frac{1000 - 932}{1000} \times 100\% = 6,8\%$

Pemeriksaan Kadar Lumpur Agregat Kasar I

Tabel 4. Hasil Analisis Kadar Lumpur Agregat Kasar I

Uraian	Berat	
	Pasir jenuh kering muka (SSD) (B_1)	1000 gr
Pasir setelah keluar oven (B_2)	979 gr	973 gr
Kandungan air ($B_1 - B_2$)	21 gr	27 gr
$Kadar\ lumpur = \frac{B_1 - B_2}{B_1} \times 100\%$	2,1 %	2,7 %

a. Kandungan air = $B_1 - B_2$
 $= 1000 - 979$
 $= 21 \text{ gram}$

b. Kadar Lumpur = $\frac{B_1 - B_2}{B_1} \times 100\%$
 $= \frac{1000 - 979}{1000} \times 100\% = 2,1\%$

Pemeriksaan Kadar Lumpur Agregat Kasar II

Tabel 4. Hasil Analisis Kadar Lumpur Agregat Kasar (Batu Tua)

Uraian	Berat	
	Pasir jenuh kering muka (SSD) (B_1)	1000 gr
Pasir setelah keluar oven (B_2)	952,06 gr	928 gr
Kandungan air ($B_1 - B_2$)	47,94 gr	72 gr
$Kadar\ lumpur = \frac{B_1 - B_2}{B_1} \times 100\%$	4,79 %	7,2 %

$$\begin{aligned}
 \text{a. Kandungan air} &= B_1 - B_2 \\
 &= 1000 - 952,06 \\
 &= 47,94 \text{ gram}
 \end{aligned}$$

$$\begin{aligned}
 \text{b. Kadar Lumpur} &= \frac{B_1 - B_2}{B_1} \times 100\% \\
 &= \frac{1000 - 952,06}{1000} \times 100\% = 4,79\%
 \end{aligned}$$

Contoh Perhitungan Kebutuhan Bahan

Perbandingan Semen : Abu (1 : 12) 20% Agregat Kasar II

Volum Cetakan:

$$p \times l \times t = 20 \times 10 \times 6 = 1200 \text{ cm}^3$$

1 Semen : 12 Abu Batu (13 Satuan)

Volum per satuan:

$$\frac{1200}{13} = 92,307 \text{ cm}^3$$

1. Kebutuhan bahan susun *paving block* per-sampel

a. Semen

$$\text{Volum} = 1 \text{ Satuan} \times \text{Volum per Satuan}$$

$$= 1 \times 92,307 \text{ cm}^3$$

$$= 92,307 \text{ cm}^3$$

$$\text{Berat} = \text{volum} \times \text{Berat Satuan Semen}$$

$$= 92,307 \text{ cm}^3 \times 3,22 \text{ gr/cm}^3 = 297,231 \text{ gr}$$

b. Abu Batu

$$\text{Volum} = 12 \text{ Satuan} \times \text{Volum per Satuan}$$

$$= 12 \times 92,307 \text{ cm}^3$$

$$= 1107,684 \text{ cm}^3$$

$$\text{Berat} = \text{volum} \times \text{Berat Jenis Satuan Abu Batu}$$

$$= 1107,684 \text{ cm}^3 \times 1,743 \text{ gr/cm}^3$$

$$= 1930,693 \text{ gr}$$

c. Agregat Kasar II (20%)

$$\text{Volum} = \frac{20}{100} \times 1107,684 \text{ cm}^3$$

$$= 221,537 \text{ cm}^3$$

$$\text{Berat} = 221,537 \text{ cm}^3 \times \text{Berat Satuan Agregat Kasar II}$$

$$= 221,537 \text{ cm}^3 \times 1,6 \text{ gr/cm}^3$$

$$= 354,460 \text{ gr}$$

d. Abu Batu (20% Agregat Kasar II)

$$\text{Berat} = \text{Berat total abu batu} - \text{berat 20\% Agregat Kasar II}$$

$$= 1930,693 \text{ gr} - 354,460 \text{ gr}$$

$$= 1576,233 \text{ gr}$$

e. Air

$$\text{Volum} = f_{as} \times \text{berat semen}$$

$$= 0,4 \times 287,228 \text{ gr}$$

$$= 118,891 \text{ ml}$$

2. Kebutuhan bahan susun paving block per-3 sampel (agregat kasar II)

a. Semen : 3 x 297,231 = 891,693 gr

b. Abu batu : 3 x 1576,233 = 4728,699 gr

c. Agregat kasar II : 3 x 354,460 = 1.063,38 gr

d. Air : 3 x 118,891 = 356,673 ml

3. Kebutuhan bahan susun paving block per-m² (agregat kasar II)

a. Semen : 50 x 297,231 = 14.861,44 gr

b. Abu batu : 50 x 1576,233 = 78811,65 gr

c. Agregat kasar II : 50 x 354,460 = 17723 gr

d. Air : 50 x 118,891 = 5.944,85 ml

Hasil Perhitungan Kebutuhan Bahan Susun Per-Sampel

Tabel 13. Kebutuhan bahan susun tiap adukan

Pc:Pab	AGR (%)	Semen (gr)	AGR (gr)	Abu Batu (gr)	Air (ml)	Jumlah Sampel
1:12 AGR Kasar I	0	297,231	0	1920,738	118,892	3
	5	297,231	82,468	1838,271	118,892	3
	10	297,231	164,935	1755,803	118,892	3
	15	297,231	347,403	1673,336	118,892	3
	20	297,231	329,871	1590,868	118,892	3
Pc:Pab	AGR (%)	Semen (gr)	AGR (gr)	Abu Batu (gr)	Air (ml)	Jumlah Sampel
1:12 AGR Kasar II	0	297,231	0	1920,738	118,892	3
	5	297,231	88,615	1832,123	118,892	3
	10	297,231	177,231	1743,508	118,892	3
	15	29,231	265,846	1654,892	118,892	3
	20	297,231	354,462	1566,277	118,892	3

Perhitungan Harga Bahan Penyusun *Paving Block*

Daftar harga bahan susun *paving block* :

- a. Semen Holcim 1 sak (40 kg) : Rp 57.000,-
 - b. Harga abu batu per-ton : Rp 70.000,-
 - c. Harga agregat kasar I per-ton : Rp 150.000,-
 - d. Harga agregat kasar II per-ton : Rp 110.000,-
-
- 1. Harga semen Holcim per-kg = Rp 57.000 : 40 kg
= Rp 1.425/kg
 - 2. Harga abu batu per-kg = Rp 70.000 : 1000
= Rp 70/kg
 - 3. Harga agregat kasar I per-kg = Rp 150.000 : 1000
= Rp 150/kg
 - 4. Harga agregat kasar II per-kg = Rp 110.000 : 1000
= Rp 110/kg

Perhitungan Biaya Produksi *Paving Block* Per-m²

1. Kebutuhan bahan susun *paving block* per-m²

- a. Semen : 50 x 297,231 = 14861,44 gr
= 14,861 kg
- b. Abu batu : 50 x 1576,233 = 78811,65 gr
= 78,811 kg
- c. Agregat Kasar II : 50 x 354,460 = 17723 gr
= 17,72 kg
- d. Air : 50 x 118,891 = 5944,85 ml

2. Biaya produksi *paving block* per- m^2

- a. Biaya semen per- m^2 = Keb. Semen per- m^2 x Harga semen per-kg
= 14,861 kg x Rp 1.425,-
= Rp 21.176,925 (A)
- b. Biaya abu batu per- m^2 = Keb. Abu batu per- m^2 x Harga abu batu per-kg
= 78,811 kg x Rp 70,-
= Rp 5.516,77 (B)
- c. Biaya agregat kasar II = Keb. Agregat kasar II per- m^2 x Harga agregat kasarII
= 17,72 kg x Rp 110,-
= Rp 1.949,2 (C)
- d. Upah tenaga per- m^2 = Rp 16.250,- (D)
- e. Total biaya produksi = A + B + C + D
= Rp 21.176,925 + Rp 5.516,77 + Rp 1.949,2 + Rp 16.250
= Rp 44.892,895

Perhitungan Kuat Tekan

Kuat Tekan = P / A

Dengan P = Beban yang diterima

A = Luas bidang tekan

Sebagai contoh data *paving block* perbandingan 1Pc:12Pab 20% Agregat kasar II

E

Dengan P = 43090 kg

A = 148,62 cm^2

Kuat Tekan = P / A

= 43090 / 148,62 cm^2

$$\begin{aligned} &= 289,934 \text{ kg/cm}^2 \\ &= (250,462 \times 9,81) / 100 \\ &= 28,267 \text{ MPa} \end{aligned}$$

Hasil Pengujian Kuat Tekan *Paving Block*

Tabel 14. Hasil uji kuat tekan *paving block* pada umur 28 hari

Campuran	Variasi	Nama	Panjang (cm)	Lebar (cm)	Tinggi (cm)	Luas (cm ²)	Peak Force (kg)	Berat (gram)	Kuat Tekan (Mpa)	Rata-rata (Mpa)
1:12 agregat kasar I	0%	A	18.3	8.3	6	152.060	19160	2282	12.360	12.117
		B	18.3	8.3	6	152.060	19120	2192	12.335	
		D	18.3	8.3	6	152.060	18080	2147	11.660	
	5%	B	18.4	8.4	6	154.730	19520	2320	12.370	12.170
		C	18.2	8.3	6	151.200	20150	2302	12.770	
		D	18.4	8.4	6	154.730	17940	2321	11.370	
	10%	A	18.2	8.3	6	151.200	22790	2360	14.450	13.483
		C	18.2	8.3	6	151.200	19920	2370	12.630	
		E	18.4	8.4	6	154.730	21090	2269	13.370	
	15%	A	18.2	8.3	6	151.200	24720	2420	15.670	16.383
		B	18.2	8.3	6	151.200	29430	2458	18.660	
		E	18.2	8.3	6	151.200	23370	2321	14.820	
20%	A	18.4	8.4	6	154.730	34400	2450	21.810	20.860	
	B	18.2	8.3	6	151.200	33240	2435	21.070		
	C	18.2	8.3	6	151.200	31080	2459	19.700		

1:12 agregat II	0%	A	18.3	8.3	6	152.060	19160	2282	12.361	12.117
		B	18.3	8.3	6	152.060	19120	2192	12.335	
		D	18.3	8.3	6	152.060	18080	2147	11.664	
	5%	A	18.3	8.3	6	152.060	31540	2346	18.090	18.000
		C	18.3	8.3	6	152.060	30590	2368	17.770	
		D	18.2	8.3	6	151.200	32390	2350	18.140	
	10%	C	18.3	8.3	6	152.060	35480	2410	19.050	18.660
		D	18.3	8.3	6	152.060	38220	2395	17.820	
		E	18.3	8.3	6	152.060	35580	2450	19.110	
	15%	C	18.3	8.3	6	152.060	59850	2455	25.280	23.893
		D	18.2	8.3	6	151.200	58120	2413	23.130	
		E	18.2	8.3	6	151.200	61050	2444	23.270	
20%	A	18.3	8.3	6	152.060	43730	2557	27.600	28.267	
	D	18.3	8.3	6	152.060	40920	2489	28.800		
	E	18.3	8.3	6	152.060	47560	2368	28.400		

Sumber : Hasil Penelitian, 2015