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Lampiran 1. Syarat mutu Semen *Portland* (SNI 15-2049-2004)

1. Syarat kimia utama

No	Uraian	Jenis Semen <i>Portland</i>				
		I	II	III	IV	V
1	SiO ₂ , % minimum	-	20,0	-	-	-
2	Al ₂ O ₃ , % maksimum	-	6,0	-	-	-
3	Fe ₂ O ₃ , % maks.	-	6,0	-	6,5	-
4	MgO, % maksimum	6,0	6,0	6,0	6,0	6,0
5	SO ₃ , % maksimum					
	Jika 3CaO.Al ₂ O ₃ ≤ 8,0	3,0	3,0	3,5	2,3	2,3
	Jika 3CaO.Al ₂ O ₃ > 8,0	3,5	-	4,5	-	-
6	Hilang Pijar, % maks.	5,0	3,0	3,0	2,5	3,0
7	Bagian tak larut, % maksimum	3,0	1,5	1,5	1,5	1,5
8	3CaO.SiO ₂ , % maks.	-	-	-	35	-
9	2CaO.SiO ₂ , % maks.	-	-	-	40	-
10	3CaO.Al ₂ O ₃ , % maks.	-	8,0	15	7	5
11	4CaO.Al ₂ O ₃ .Fe ₂ O ₃ + 2(3CaO.Al ₂ O ₃) atau 4CaO.Al ₂ O ₃ .Fe ₂ O ₃ + 2CaO.Fe ₂ O ₃ , % maks.	-	-	-	-	25

2. Syarat kimia tambahan

No	Uraian	Jenis Semen <i>Portland</i>				
		I	II	III	IV	V
1	3CaO.Al ₂ O ₃ , % maks.	-	-	8	-	-
2	3CaO.Al ₂ O ₃ , % min.	-	-	5	-	-
3	3CaO.SiO ₂ + 2(3CaO.Al ₂ O ₃), % maks.	-	58	-	-	-
4	Alkali, sebagai (Na ₂ O + 0,658 K ₂ O), % maks	0,60	0,60	0,60	0,60	0,60

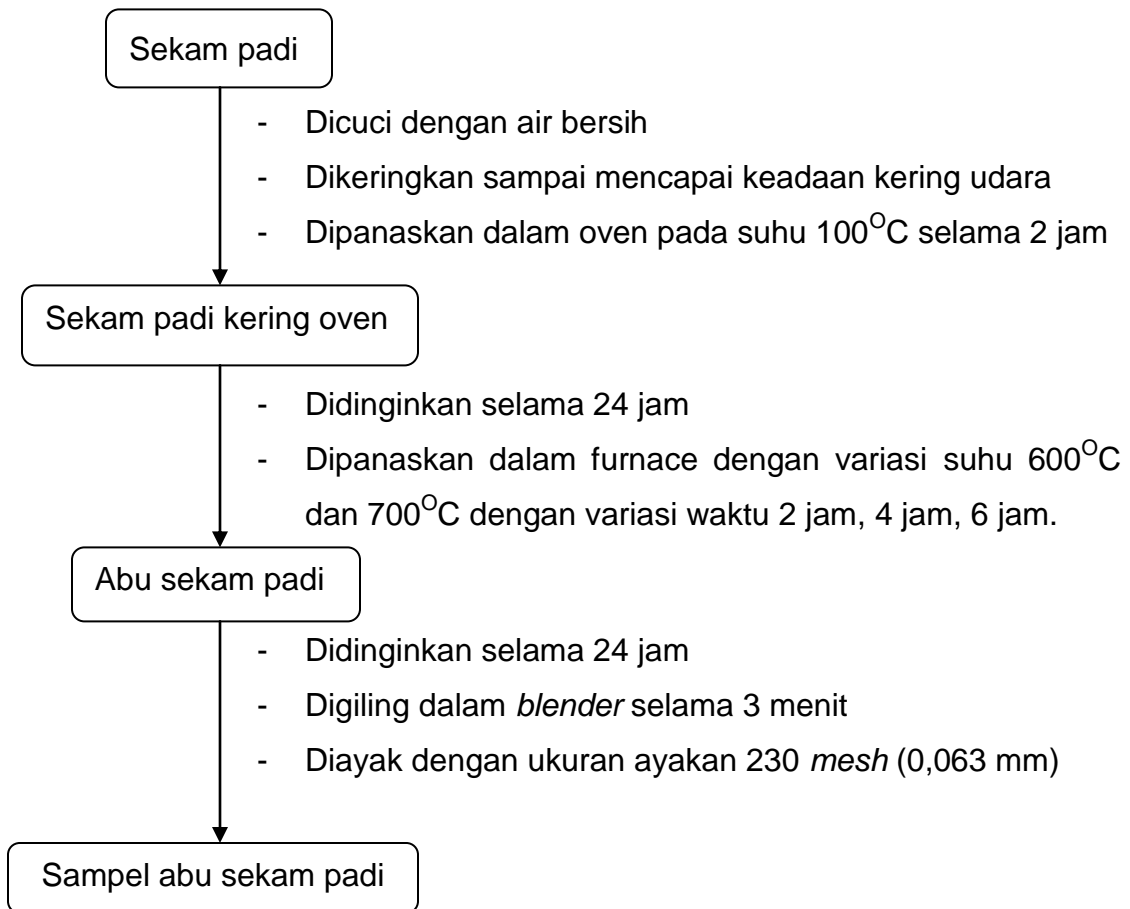
3. Syarat fisika utama

No	Uraian	Jenis Semen <i>Portland</i>				
		I	II	III	IV	V
1	Kehalusan : Uji permeabilitas udara dengan : Alat Turbidimeter, m ² /kg, min Alat Blaine, m ² /kg, min	160	160	160	160	160
		280	280	280	280	280
2	Kekekalan :Pemuaiian dengan autoclave, % maks.	0,80	0,80	0,80	0,80	0,80
3	Kuat tekan :					
	Umur 1 hari, kg/cm ² , min.	-	-	120	-	-
	Umur 3 hari, kg/cm ² , min.	125	100 70	240	-	80
	Umur 7 hari, kg/cm ² , min.	200	175 120 ^{a)}	-	70	150
	Umur 28 hari, kg/cm ² , min.	280	-	-	170	210
4	Waktu pengikatan (metode alternatif) dengan alat :					
	Gillmore : -Awal, menit, min.	60	60	60	60	60
	-Akhir, menit,maks.	600	600	600	600	600
	Vicat : -Awal, menit, min.	45	45	45	45	45
	-Akhir, menit, maks.	375	375	375	375	375

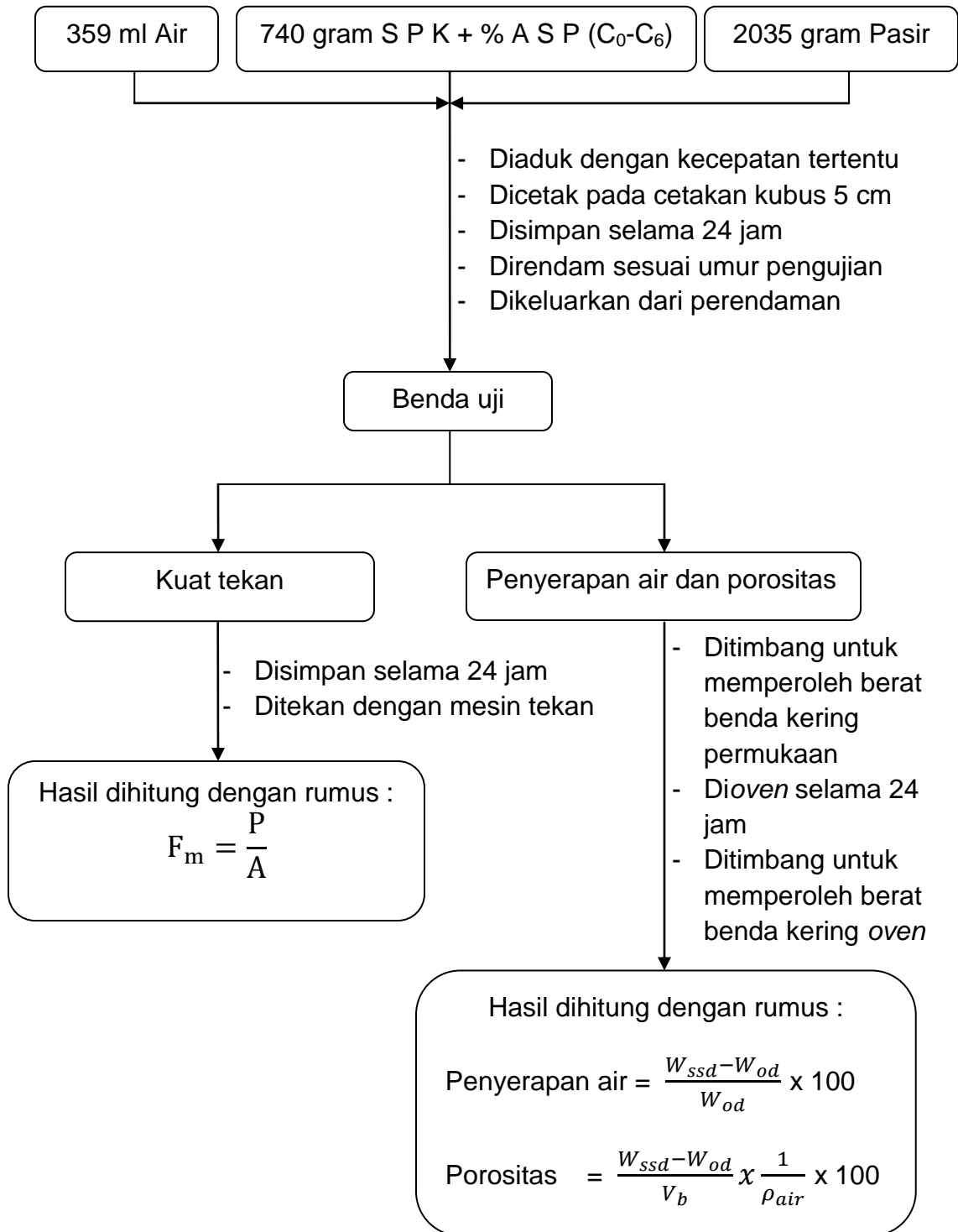
4. Syarat fisika tambahan

No	Uraian	Jenis Semen <i>Portland</i>				
		I	II	III	IV	V
1	Pengikatan semu penetrasi akhir, % minimum	50	50	50	50	50
2	Kalor hidrasi Umur 7 hari, kal/gram, maks. Umur 28 hari, kal/gram, maks.	-	70	-	60	-
		-	-	-	70	-
3	Kuat tekan : Umur 28 hari, kg/cm ² , minimum	-	280	-	-	-
4	Pemuaiian karena sulfat 14 hari, %, maksimum	-	220	-	-	0,040
5	Kandungan udara mortar, % volume, maksimum	12	12	12	12	12

Lampiran 2. Prosedur pembuatan abu sekam padi



Lampiran 3. Prosedur pembuatan benda uji dan pengujian



Lampiran 4. Hasil X-RF sampel

2013-05-15 17:09

ThermoFisher-XRF/UniQuant Analysis Report
 SAMPLE ANALYSIS REPORT
 ARL QUANT'X EDXRF ANALYZER

THERMO FISHER SCIENTIFIC
 UNIQUANT(TM) STANDARDLESS METHOD

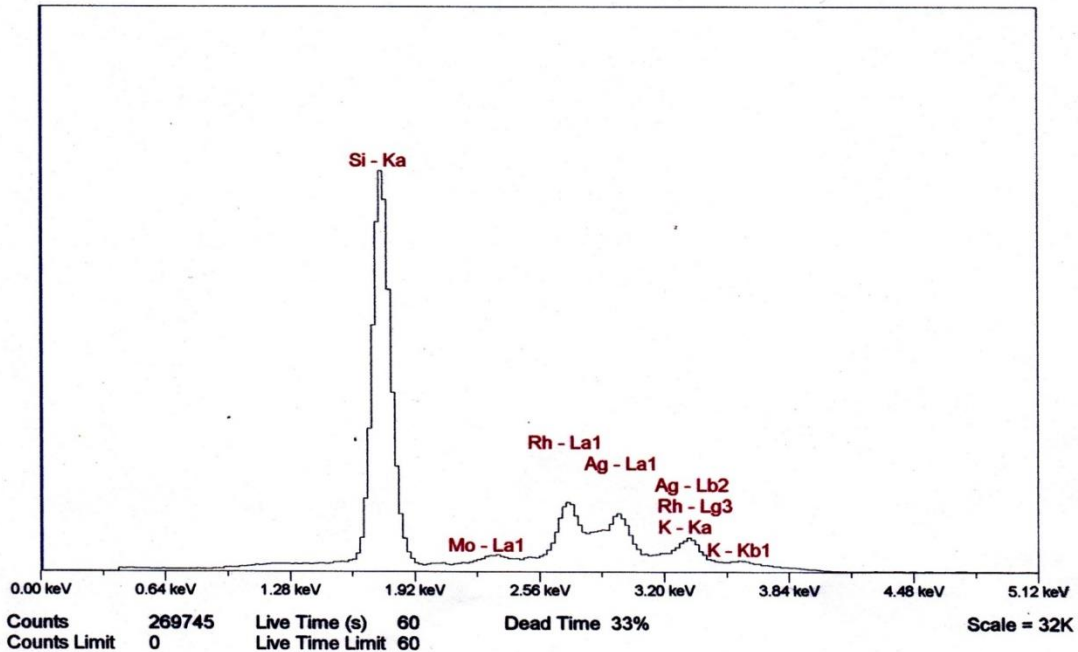
C:\UQed\USER\Quant'X\JOB\JOB.058

Sample ident = Loth#ASP4#700

Compound	m/m%	StdErr	El	m/m%	StdErr
SiO2	97.59	0.08	Si	45.62	0.04
K2O	1.55	0.06	K	1.29	0.05
CaO	0.467	0.052	Ca	0.334	0.038
P2O5	0.238	0.083	Px	0.104	0.036
Fe2O3	0.0569	0.0083	Fe	0.0398	0.0058
MnO	0.0499	0.0055	Mn	0.0386	0.0043
ZnO	0.0210	0.0022	Zn	0.0169	0.0018
Rb2O	0.0073	0.0012	Rb	0.0067	0.0011

KnownConc= 0 REST= 0 D/S= 0
 Sum Conc's before normalisation to 100% : 80.3 %

Spectrum Acquired: Wednesday, May 15, 2013 16:58:41 Sample: Loth#ASP4#700
 4 kV Cursor = 0.01 keV
 1.98 mA (Auto) Counts = 0
 Filter: No Filter



2013-05-15 18:05

ThermoFisher-XRF/UniQuant Analysis Report
 SAMPLE ANALYSIS REPORT
 ARL QUANT'X EDXRF ANALYZER

THERMO FISHER SCIENTIFIC
 UNIQUANT (TM) STANDARDLESS METHOD

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Sample ident = Loth#PCC#Kupang

Compound	m/m%	StdErr	El	m/m%	StdErr
CaO	70.96	0.35	Ca	50.73	0.25
SiO2	19.10	0.29	Si	8.93	0.14
SO3	4.81	1.62	Sx	1.92	0.65
Fe2O3	3.89	0.10	Fe	2.72	0.07
K2O	0.81	0.20	K	0.67	0.16
TiO2	0.310	0.036	Ti	0.186	0.021
V2O5	0.073	0.033	V	0.041	0.019
ZrO2	0.0244	0.0058	Zr	0.0181	0.0043
Nb2O5	0.0116	0.0037	Nb	0.0081	0.0026
SnO2	0.0053	0.0014	Sn	0.0042	0.0011
Sb2O3	0.0053	0.0014	Sb	0.0044	0.0012

KnownConc= 0

REST= 0

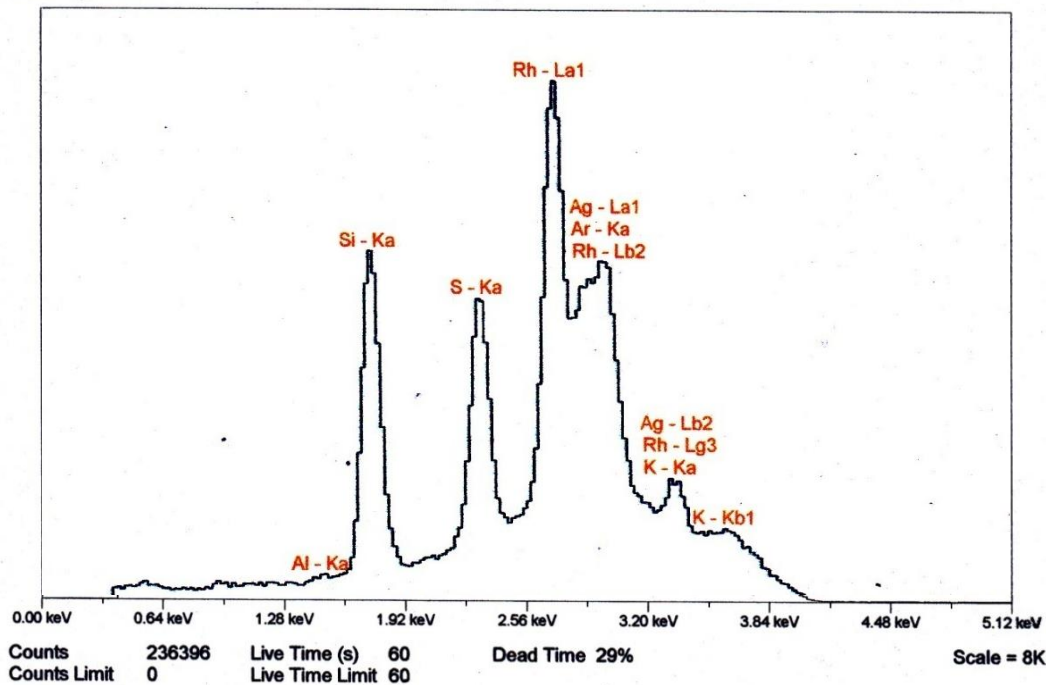
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Sum Conc's before normalisation to 100% : 62.6 %

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Sample: Loth#PCC#Kupang



2013-07-10 15:08

ThermoFisher-XRF/UniQuant Analysis Report
 SAMPLE ANALYSIS REPORT
 ARL QUANT'X EDXRF ANALYZER

THERMO FISHER SCIENTIFIC
 UNIQUANT(TM) STANDARDLESS METHOD

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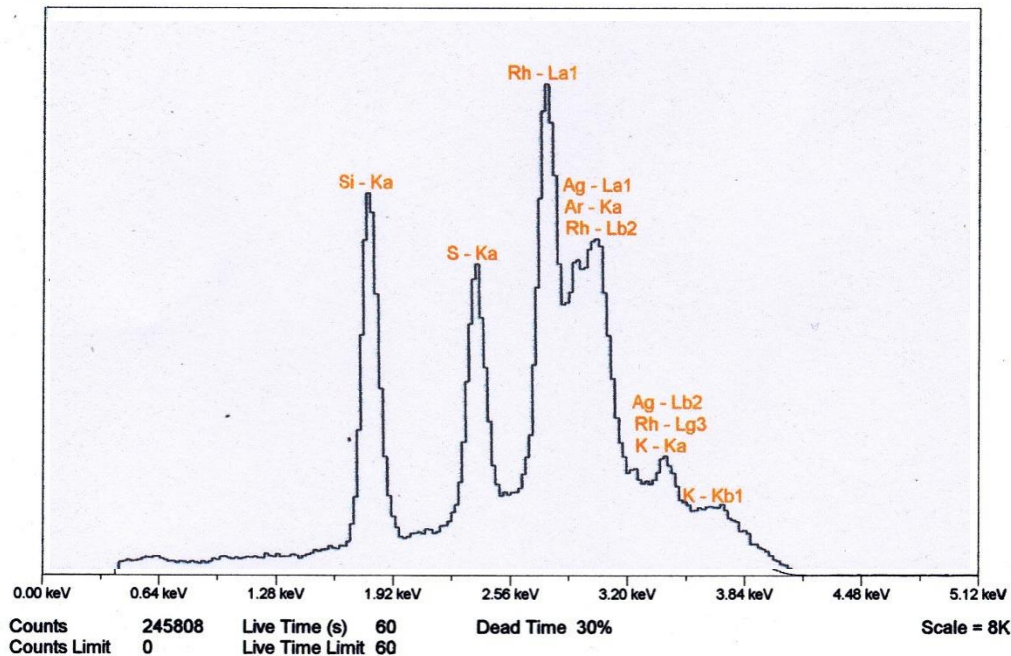
Sample ident = Loth#ASP_1%

Compound	m/m%	StdErr	El	m/m%	StdErr
CaO	67.45	0.73	Ca	48.23	0.52
SiO2	22.13	0.37	Si	10.34	0.17
Fe2O3	3.84	0.10	Fe	2.69	0.07
SO3	3.75	1.81	Sx	1.50	0.72
Al2O3	1.70	0.85	Al	0.90	0.45
K2O	0.75	0.21	K	0.62	0.17
TiO2	0.309	0.037	Ti	0.185	0.022
ZrO2	0.0224	0.0062	Zr	0.0166	0.0046
Nb2O5	0.0184	0.0024	Nb	0.0129	0.0016
MoO3	0.0155	0.0026	Mo	0.0103	0.0018
SnO2	0.0052	0.0012	Sn	0.0041	0.0010

KnownConc= 0 REST= 0 D/S= 0
 Sum Conc's before normalisation to 100% : 60.4 %

Spectrum Acquired: Wednesday, July 10, 2013 14:55:51

4 KV Cursor = 0.01 keV Sample: Loth#ASP_1%_5MHomogen
 1.98 mA (Auto) Counts = 0
 Filter: No Filter



2013-06-25 14:51

ThermoFisher-XRF/UniQuant Analysis Report
 SAMPLE ANALYSIS REPORT
 ARL QUANT'X EDXRF ANALYZER

THERMO FISHER SCIENTIFIC
UNIQUANT (TM) STANDARDLESS METHOD

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Sample ident = Loth#Semen+ASP2%

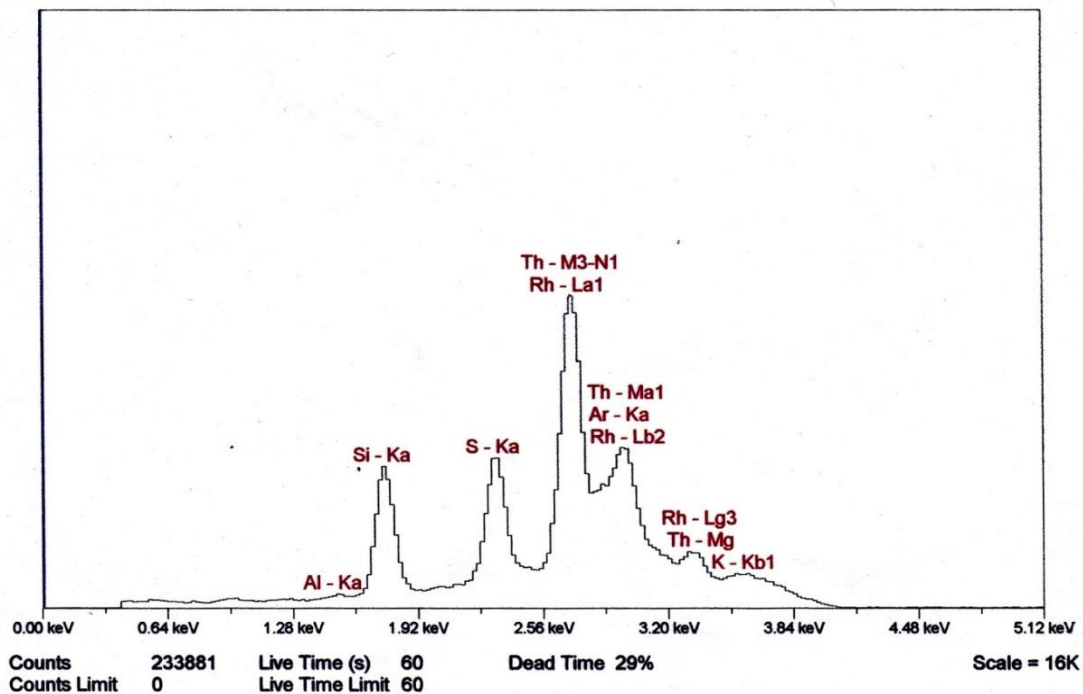
Compound	m/m%	StdErr	El	m/m%	StdErr
CaO	66.99	0.63	Ca	47.90	0.45
SiO2	22.16	0.35	Si	10.36	0.16
SO3	4.43	1.52	Sx	1.77	0.61
Fe2O3	3.45	0.09	Fe	2.41	0.06
Al2O3	1.92	0.78	Al	1.02	0.41
K2O	0.74	0.19	K	0.62	0.16
TiO2	0.229	0.038	Ti	0.137	0.023
ZrO2	0.0203	0.0053	Zr	0.0150	0.0039
Nb2O5	0.0179	0.0022	Nb	0.0125	0.0015
MoO3	0.0151	0.0024	Mo	0.0101	0.0016
Sb2O3	0.0056	0.0011	Sb	0.0047	0.0009

KnownConc= 0 REST= 0 D/S= 0
 Sum Conc's before normalisation to 100% : 62.7 %

Spectrum Acquired: Tuesday, June 25, 2013 14:42:07

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 Filter: No Filter

Sample: Loth#Semen+ASP2%



2013-06-25 15:04

ThermoFisher-XRF/UniQuant Analysis ReportSAMPLE ANALYSIS REPORT
ARL QUANT'X EDXRF ANALYZERTHERMO FISHER SCIENTIFIC
UNIQUANT (TM) STANDARDLESS METHOD

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Sample ident = Loth#Semen+ASP3%

Compound	m/m%	StdErr	El	m/m%	StdErr
CaO	68.36	0.61	Ca	48.88	0.44
SiO2	24.83	0.36	Si	11.61	0.17
Fe2O3	3.77	0.10	Fe	2.64	0.07
Al2O3	1.84	0.79	Al	0.97	0.42
K2O	0.86	0.19	K	0.72	0.16
TiO2	0.281	0.046	Ti	0.168	0.027
ZrO2	0.0226	0.0056	Zr	0.0167	0.0041
Nb2O5	0.0133	0.0026	Nb	0.0093	0.0018
MoO3	0.0094	0.0029	Mo	0.0063	0.0020

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REST= 0

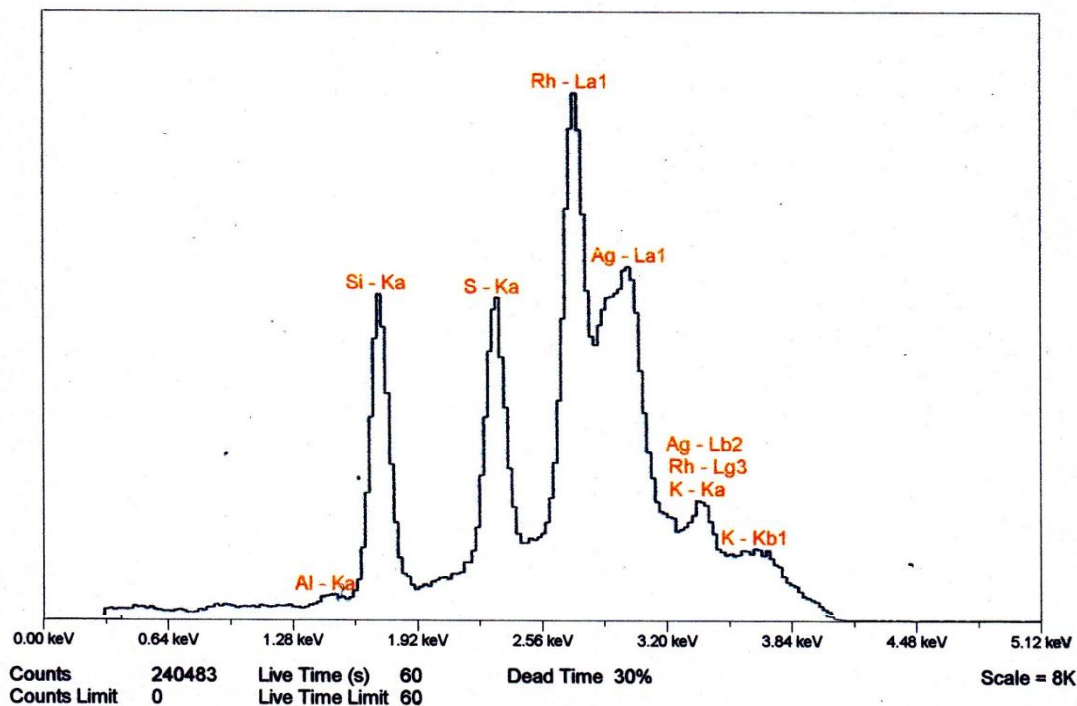
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Sum Conc's before normalisation to 100% : 62.3 %

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Sample: Loth#Semen+ASP3%



2013-06-25 16:00

ThermoFisher-XRF/UniQuant Analysis ReportSAMPLE ANALYSIS REPORT
ARL QUANT'X EDXRF ANALYZERTHERMO FISHER SCIENTIFIC
UNIQUANT (TM) STANDARDLESS METHOD

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Sample ident = Loth#Semen+ASP5%

Compound	m/m%	StdErr	El	m/m%	StdErr
CaO	67.75	0.35	Ca	48.44	0.25
SiO2	27.26	0.30	Si	12.74	0.14
Fe2O3	3.65	0.09	Fe	2.55	0.06
K2O	0.96	0.19	K	0.79	0.15
TiO2	0.304	0.033	Ti	0.182	0.020
ZrO2	0.0201	0.0054	Zr	0.0149	0.0040
Nb2O5	0.0177	0.0022	Nb	0.0124	0.0015
MoO3	0.0157	0.0024	Mo	0.0105	0.0016
SnO2	0.0055	0.0011	Sn	0.0043	0.0009
Sb2O3	0.0054	0.0011	Sb	0.0045	0.0009

KnownConc= 0

REST= 0

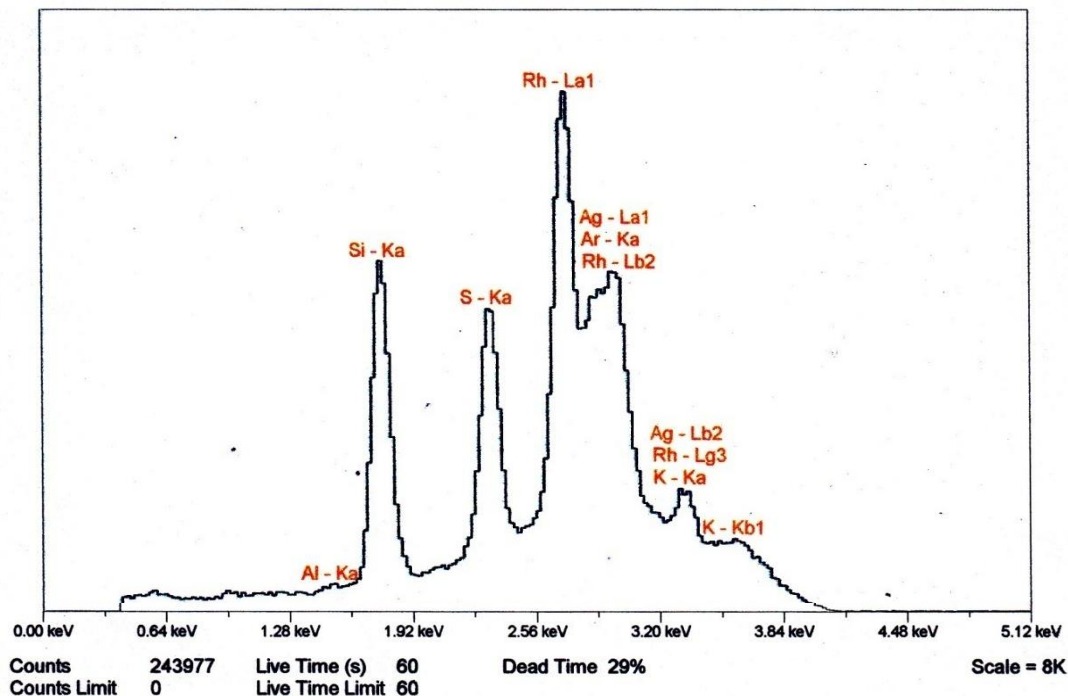
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Sum Conc's before normalisation to 100% : 64.9 %

Spectrum Acquired: Tuesday, June 25, 2013 15:19:49

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Sample: Loth#Semen+ASP5%



2013-05-24 16:14

ThermoFisher-XRF/UniQuant Analysis Report
SAMPLE ANALYSIS REPORT
ARL QUANT'X EDXRF ANALYZER

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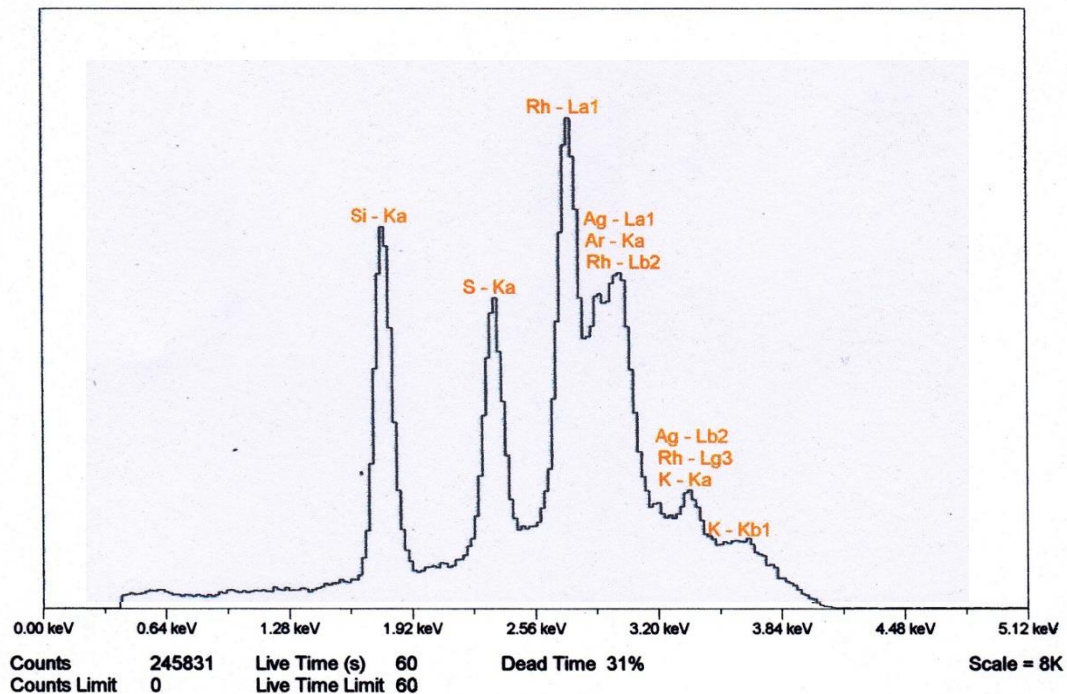
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Sample ident = Loth#ASP6%

Compound	m/m%	StdErr	El	m/m%	StdErr
CaO	65.70	0.27	Ca	46.98	0.19
SiO2	29.51	0.29	Si	13.80	0.14
Fe2O3	3.52	0.09	Fe	2.46	0.06
K2O	0.89	0.19	K	0.74	0.15
TiO2	0.310	0.039	Ti	0.186	0.024
ZrO2	0.0215	0.0053	Zr	0.0159	0.0039
Nb2O5	0.0139	0.0028	Nb	0.0097	0.0020
MoO3	0.0120	0.0030	Mo	0.0080	0.0020
Sb2O3	0.0053	0.0012	Sb	0.0044	0.0010

KnownConc= 0 REST= 0 D/S= 0
Sum Conc's before normalisation to 100% : 64.9 %

Spectrum Acquired: Friday, May 24, 2013 15:58:45

4 kV Cursor = 0.01 keV Sample: Loth#ASP6%
1.98 mA (Auto) Counts = 0
Filter: No Filter



Lampiran 5. Perhitungan konsentrasi mineral semen

Perhitungan stoikiometri Bogue dengan $\text{Al}_2\text{O}_3 / \text{Fe}_2\text{O}_3 < 0,64$:

$$3\text{CaO} \cdot \text{SiO}_2 = (4,071 \times \% \text{CaO}) - (7,600 \times \% \text{SiO}_2) - 4,479 \times \text{Al}_2\text{O}_3 - (2,859 \times \% \text{Fe}_2\text{O}_3) - (2,852 \times \% \text{SO}_3)$$

$$2\text{CaO} \cdot \text{SiO}_2 = (2,867 \times \% \text{SiO}_2) - (0,7544 \times \% \text{CaO} \cdot \text{SiO}_2)$$

$$3\text{CaO} \cdot \text{Al}_2\text{O}_3 = 0$$

$$4 \text{CaO} \cdot \text{Al}_2\text{O}_3 \cdot \text{Fe}_2\text{O}_3 = (2,1 \times \% \text{Al}_2\text{O}_3) + (1,702 \times \% \text{Fe}_2\text{O}_3)$$

1. Untuk Semen *Portland* Komposit tanpa Abu Sekam Padi

$$3\text{CaO} \cdot \text{SiO}_2 = (4,071 \times 70,96) - (7,600 \times 19,10) - (4,479 \times 0) - (2,859 \times 3,89) - (2,852 \times 4,81)$$

$$= 288,878 - 145,16 - 11,12151 - 13,71812 = \mathbf{118,878}$$

$$2\text{CaO} \cdot \text{SiO}_2 = (2,867 \times 19,10) - (0,7544 \times 118,878) = 54,7597 - 89,682$$

$$= - \mathbf{34,92} \text{ (negatif sehingga dianggap tidak ada).}$$

$$3\text{CaO} \cdot \text{Al}_2\text{O}_3 = \mathbf{0}$$

$$4\text{CaO} \cdot \text{Al}_2\text{O}_3 \cdot \text{Fe}_2\text{O}_3 = (2,1 \times 0) + (1,702 \times 3,89) = \mathbf{6,621}$$

2. Untuk Semen *Portland* Komposit dengan 1 % Abu Sekam Padi

$$3\text{CaO} \cdot \text{SiO}_2 = (4,071 \times 67,45) - (7,600 \times 22,13) - (4,479 \times 1,70) - (2,859 \times 3,84) - (2,852 \times 3,75)$$

$$= 274,58895 - 168,118 - 7,6143 - 10,97856 - 10,695 = \mathbf{77,11309}$$

$$2\text{CaO} \cdot \text{SiO}_2 = (2,867 \times 22,13) - (0,7544 \times 77,11309)$$

$$= 63,44671 - 58,17411309 = \mathbf{5,272}$$

$$3\text{CaO} \cdot \text{Al}_2\text{O}_3 = \mathbf{0}$$

$$4\text{CaO} \cdot \text{Al}_2\text{O}_3 \cdot \text{Fe}_2\text{O}_3 = (2,1 \times 1,70) + (1,702 \times 3,84)$$

$$= 3,57 + 6,53568 = \mathbf{10,105}$$

3. Untuk Semen *Portland* Komposit dengan 2 % Abu Sekam Padi

$$3\text{CaO} \cdot \text{SiO}_2 = (4,071 \times 66,99) - (7,600 \times 22,16) - (4,479 \times 1,92) - (2,859 \times 3,45) - (2,852 \times 4,43)$$

$$= 272,71629 - 168,416 - 8,59968 - 9,86355 - 12,63436 = \mathbf{73,2027}$$

$$2\text{CaO} \cdot \text{SiO}_2 = (2,867 \times 22,16) - (0,7544 \times 73,2027)$$

$$= 63,53272 - 55,22411688 = \mathbf{8,308}$$

$$3\text{CaO} \cdot \text{Al}_2\text{O}_3 = \mathbf{0}$$

$$4\text{CaO} \cdot \text{Al}_2\text{O}_3 \cdot \text{Fe}_2\text{O}_3 = (2,1 \times 1,92) + (1,702 \times 3,45) = 4,032 + 5,8719 = \mathbf{9,903}$$

4. Untuk Semen *Portland* Komposit dengan 3 % Abu Sekam Padi

$$\begin{aligned}
 3\text{CaO} \cdot \text{SiO}_2 &= (4,071 \times 68,36) - (7,600 \times 24,83) - (4,479 \times 1,84) - (2,859 \times 3,77) - \\
 &\quad (2,852 \times 0) \\
 &= 278,29356 - 188,708 - 8,24136 - 10,77843 = \mathbf{70,56577} \\
 2\text{CaO} \cdot \text{SiO}_2 &= (2,867 \times 24,83) - (0,7544 \times 70,56577) \\
 &= 71,18761 - 53,234816888 = \mathbf{17,952} \\
 3\text{CaO} \cdot \text{Al}_2\text{O}_3 &= \mathbf{0} \\
 4\text{CaO} \cdot \text{Al}_2\text{O}_3 \cdot \text{Fe}_2\text{O}_3 &= (2,1 \times 1,84) + (1,702 \times 3,77) = 3,864 + 6,41654 = \mathbf{10,280}
 \end{aligned}$$

Lampiran 6. Data dan hasil pengujian kuat tekan

1. Pengujian kuat tekan umur 3 hari

% ASP	Luas (mm ³)	Gaya beban (N)	Kuat tekan (MPa)	Kuat tekan (kg/cm ²)	Kuat tekan rata-rata (kg/cm ²)
0	2500	14700	5,88	58,8	82,67
	2500	24300	9,72	97,2	
	2500	23000	9,20	92	
1	2500	24200	9,68	96,8	105,07
	2500	29600	11,84	118,4	
	2500	25000	10	100	
2	2500	27800	11,12	111,2	108,80
	2500	26400	10,56	105,6	
	2500	27400	10,96	109,6	
3	2500	24600	9,84	98,4	107,07
	2500	26200	10,48	104,8	
	2500	29500	11,80	118	
4	2500	23600	9,44	94,4	102,80
	2500	28000	11,2	112	
	2500	25500	10,2	102	
5	2500	21400	8,56	85,6	90,67
	2500	24200	9,68	96,8	
	2500	22400	8,96	89,6	
6	2500	22300	8,92	89,2	89,20
	2500	20400	8,16	81,6	
	2500	24200	9,68	96,8	

2. Pengujian kuat tekan umur 7 hari

% ASP	Luas (mm ²)	Gaya (N)	Kuat tekan (MPa)	Kuat tekan (kg/cm ²)	Kuat tekan rata-rata (kg/cm)
0	2500	28500	11,40	114	108,80
	2500	32100	12,84	128,4	
	2500	21000	8,40	84	
1	2500	39000	15,60	156	153,47
	2500	37600	15,04	150,4	
	2500	38500	15,40	154	
2	2500	40200	16,08	160,8	158,67
	2500	39800	15,92	159,2	
	2500	39000	15,60	156,0	
3	2500	40600	16,24	162,4	155,73
	2500	37400	14,96	149,6	
	2500	38800	15,52	155,2	
4	2500	41600	16,64	166,4	150,67
	2500	37700	15,08	150,8	
	2500	33700	13,48	134,8	
5	2500	35100	14,04	140,4	135,60
	2500	32800	13,12	131,2	
	2500	33800	13,52	135,2	
6	2500	22800	9,12	91,2	100,53
	2500	25000	10	100	
	2500	27600	11,04	110,4	

3. Pengujian kuat tekan umur 28 hari

% ASP	Luas (mm ³)	Gaya (N)	Kuat tekan (MPa)	Kuat tekan (kg/cm ²)	Kuat tekan rata-rata (kg/cm ²)
0	2500	60000	24	240	197,33
	2500	52000	20,80	208	
	2500	36000	14,40	144	
1	2500	71100	28,44	284,4	287,87
	2500	64800	25,92	259,2	
	2500	80000	32,02	320,2	
2	2500	72200	28,88	288,8	317,20
	2500	79800	31,92	319,2	
	2500	85900	34,36	343,6	
3	2500	56200	22,48	224,8	236,13
	2500	54100	21,64	216,4	
	2500	66800	26,72	267,2	
4	2500	42800	17,12	171,2	164,27
	2500	36600	14,64	146,4	
	2500	43800	17,52	175,2	
5	2500	34600	13,84	138,4	140,27
	2500	33600	13,44	134,4	
	2500	37000	14,80	148	
6	2500	39600	15,84	158,4	127,73
	2500	20800	8,32	83,2	
	2500	35400	14,16	141,6	

Lampiran 7. Data hasil uji penyerapan air dan porositas pada umur 28 hari

% ASP	Berat kering permukaan (gr)	Berat kering oven (gr)	Penyerapan air (%)		Porositas (%)	
0	252,9	233,3	8,40	9,22	15,68	17,59
	275,7	249,4	10,54		21,04	
	253,2	232,9	8,72		16,04	
1	284,1	265,4	7,05	6,79	14,96	14,35
	278,3	261,6	6,38		13,36	
	283	264,6	6,95		14,72	
2	266,3	262,4	1,48	2,51	3,12	5,36
	276,9	269,1	2,89		6,24	
	273,6	265,2	3,16		6,72	
3	268,5	248,4	8,09	8,11	16,08	15,01
	241,9	224,3	7,84		14,08	
	240	221,4	8,40		14,88	
4	220,4	198,7	10,92	10,08	17,36	17,63
	253,9	230,9	9,96		18,40	
	250	228,6	9,36		17,12	
5	266,4	240,8	10,63	11,25	20,48	20,03
	237,5	212,7	11,65		19,84	
	239,7	215	11,48		19,76	
6	258,9	232,1	11,54	11,50	21,44	20,37
	235,3	211,5	11,25		19,04	
	246	220,2	11,71		20,64	