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Appendix – I

Reuse/Recycle Potential of Rejected Ceramic Glazed Tiles

Table I-1: Reusing/ recycling potentials of rejected ceramic tiles

Application	**As Recycled Aggregate**		**As an Active Additive** (with pozzolanic characteristics)		**As an Alternative Raw Material**	**Remarks**
	As a Coarse Aggregate (total/ partial replacement of natural stone aggregate)	**As a Fine Aggregate** (total/ partial replacement of natural river or sea sand)	**As a Hydraulic Binder**	**As a Filler**		
Non Structural Concrete	✓ (30-100%)	✓ (30-100%)				Studies reviled good abrasion resistance, good tensile strength and increased durability
Reinforced Concrete		✓				
Structural Concrete	✓ (10-20%)	✓ (25-50%)				
Precast Concrete Blocks	✓ (4-31.5 mm)	✓	✓ (Partial replacement of Portland cement)			Can be utilized as sub-base paving blocks, seating blocks in recreational areas, roofing tiles, drain caver etc.
Concrete roofing tiles		✓ (5-10%)	✓ (Partial replacement of Portland cement: 5-15%)			
Bricks			✓ (10%)			
Mortar		✓ (20-50%)				
Pozzolanic Cements			✓ (Partial replacement of Portland cement:<30%)			Substitution percentages of below 30% had no negative effects on the mechanical behaviour of Portland cement Endow the cements with positive characteristics - increase in mechanical strength in the medium and long term - enhance the chemical resistance of concrete to aggressive agents, which has a positive impact on the material's service life
Unrefined Cement					✓	
Stone Mastic Asphalt (SMA)				✓		As fillers in asphalt concrete
Road Sub-Base Material					✓	Mixing with natural soil, sand and crushed aggregate
Backfill Material					✓	Mixing with lime, zeolite and cement
Improved Soil Expansion Material					✓ (40%)	Mixing ceramic tile dust with Na.bentonite
Cement clinker production					✓ (<0.05%)	Technical feasibility depend on the process conditions, kiln type and condition and other alternative fuels and raw materials utilized in the process

Appendix – II

Details and Specifications of Machinery, Analytical Equipments and Measuring Instruments Utilized For the Study

Clamp On Power HiTester

Manufacturer’s Name	: HIOKI E.E. CORPORATION
Manufacturer’s Address	: 81 Koizumi, Ueda, Nagano 386-1192, Japan
Product Name	: CLAMP ON POWER HiTESTER
Model Number	: 3286-20
Accessory	: 9635 VOLTAGE CORD
Options	: 9635-01 VOLTAGE CORD
Safety	: EN61010-1:2001, EN61010-031:2002, EN61010-2-032:2002
EMC	: EN61326-2-2-2006, Class B Equipment, Portable test, measuring and monitoring equipment used in low voltage distribution systems

Comply with the requirements of the Low Voltage Directive 2006/95/EC and the EMC Directive 2004/108/EC

Appendix – III

Details of Power Meter Readings

Table III-1: Power Meter readings during hammer milling process

Mea. No.	Power (kW)	Mea. No.	Power (kW)
1	1.33	20	1.66
2	1.39	21	1.58
3	1.40	22	1.50
4	1.48	23	1.53
5	1.56	24	1.76
6	1.41	25	1.82
7	1.51	26	1.83
8	1.44	27	1.76
9	1.54	28	1.83
10	1.62	29	1.74
11	1.66	30	1.85
12	1.55	31	1.72
13	1.52	32	1.56
14	1.70	33	1.54
15	1.68	34	1.52
16	1.58	35	1.46
17	1.55	36	1.54
18	1.58	37	1.57
19	1.72	38	1.58

Table III-2: Power Meter readings during ball milling process

Mea. No.	Power (kW)	Mea. No.	Power (kW)
1	1.10	33	1.03
2	1.11	34	1.04
3	1.09	35	1.03
4	1.07	36	1.05
5	1.10	37	1.05
6	1.09	38	1.05
7	1.08	39	1.04
8	1.11	40	1.04
9	1.10	41	1.03
10	1.08	42	1.03
11	1.10	43	1.03
12	1.09	44	1.04
13	1.04	45	1.06
14	1.03	46	1.05
15	1.05	47	1.05
16	1.04	48	1.04
17	1.04	49	1.03
18	1.07	50	1.04
19	1.03	51	1.04
20	1.04	52	1.04
21	1.04	53	1.04
22	1.04	54	1.04
23	1.03	55	1.03
24	1.04	56	1.04
25	1.04	57	1.03
26	1.03	58	1.03
27	1.05	59	1.03
28	1.04	60	1.04
29	1.04	61	1.04
30	1.03	62	1.04
31	1.03	63	1.03
32	1.03	64	1.03

Appendix – IV

PSD Graphs obtained from Particle size Analyzer for the Ball Milled Products

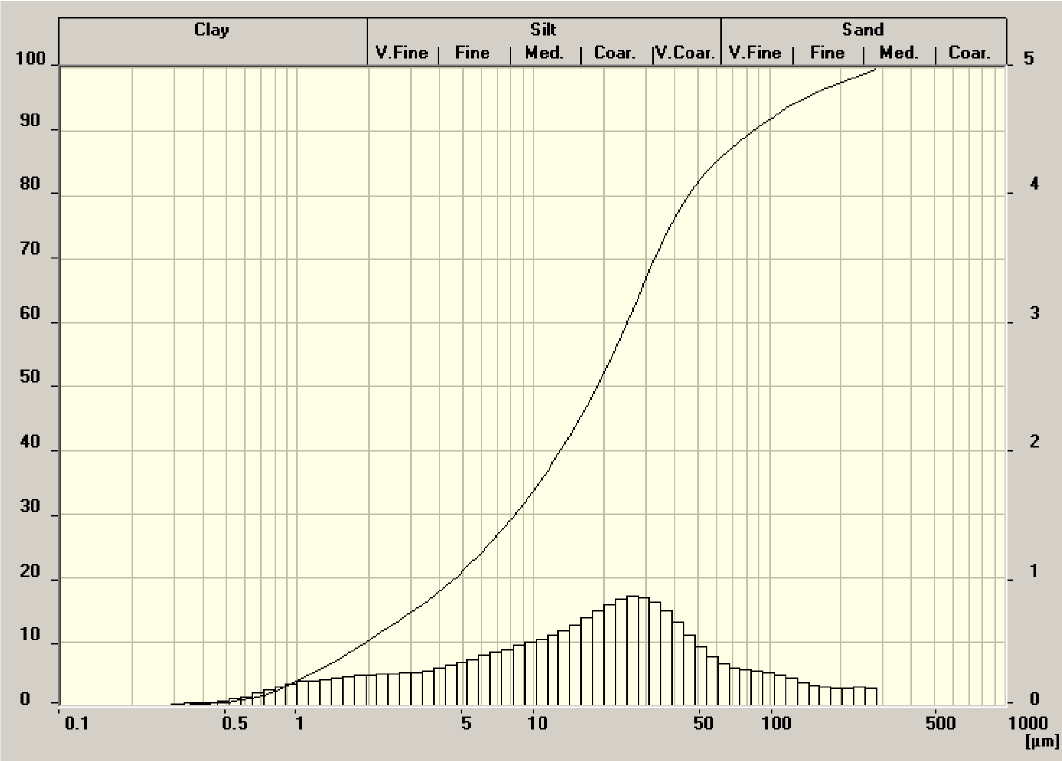

Figure IV-1: 4hrs Ball Milled Product - Sample 1

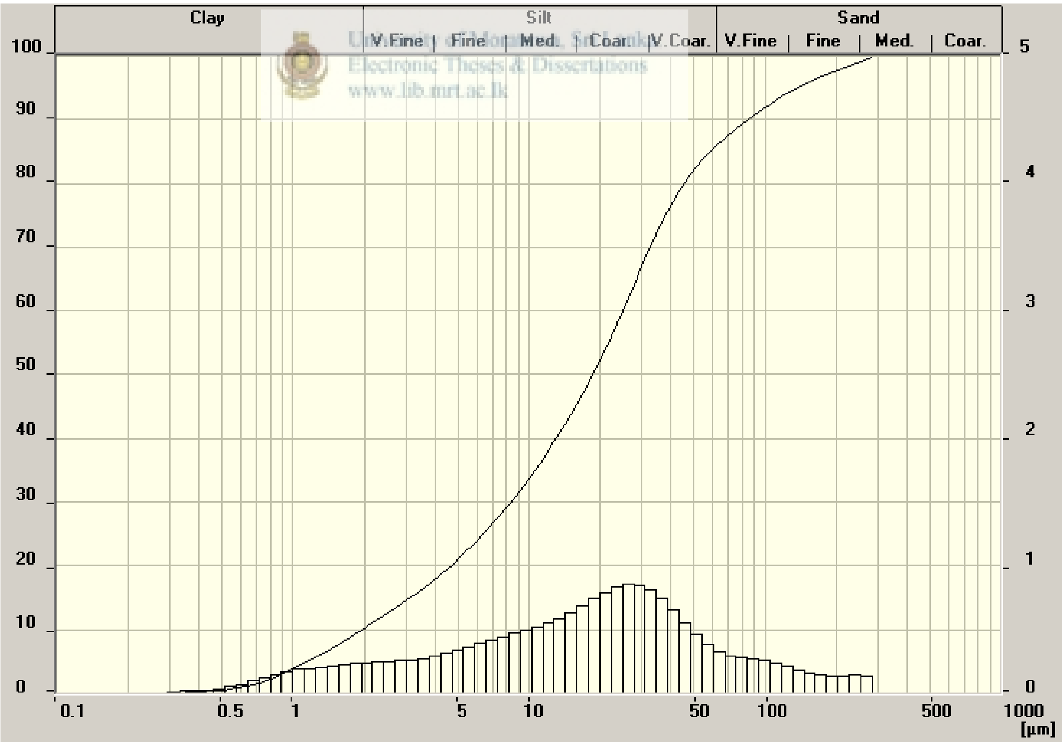

Figure IV-2: 4hrs Ball Milled Product - Sample 2

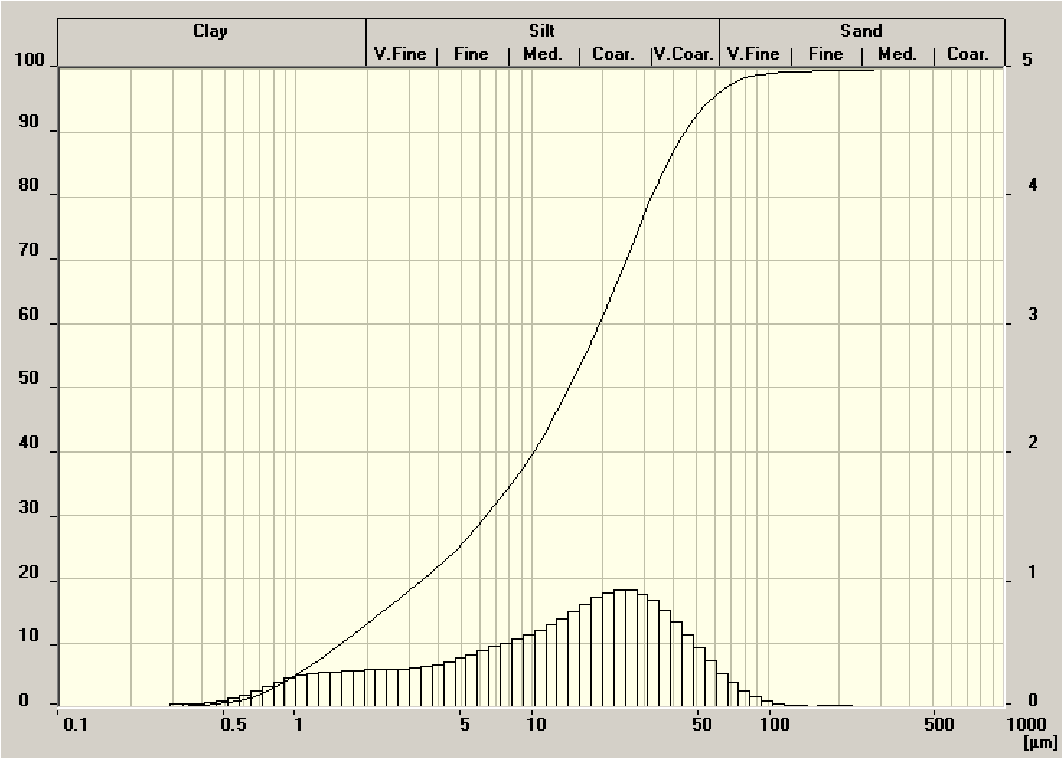

Figure IV-3: 8hrs Ball Milled Product - Sample 1

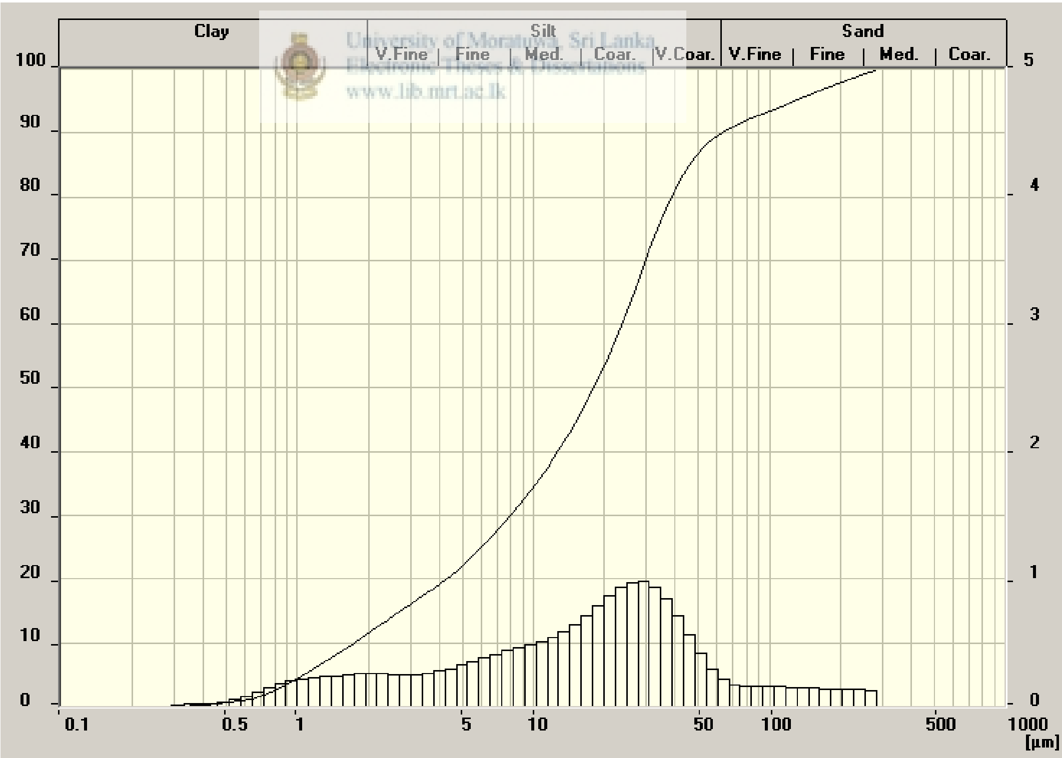

Figure IV-4: 8hrs Ball Milled Product - Sample 2

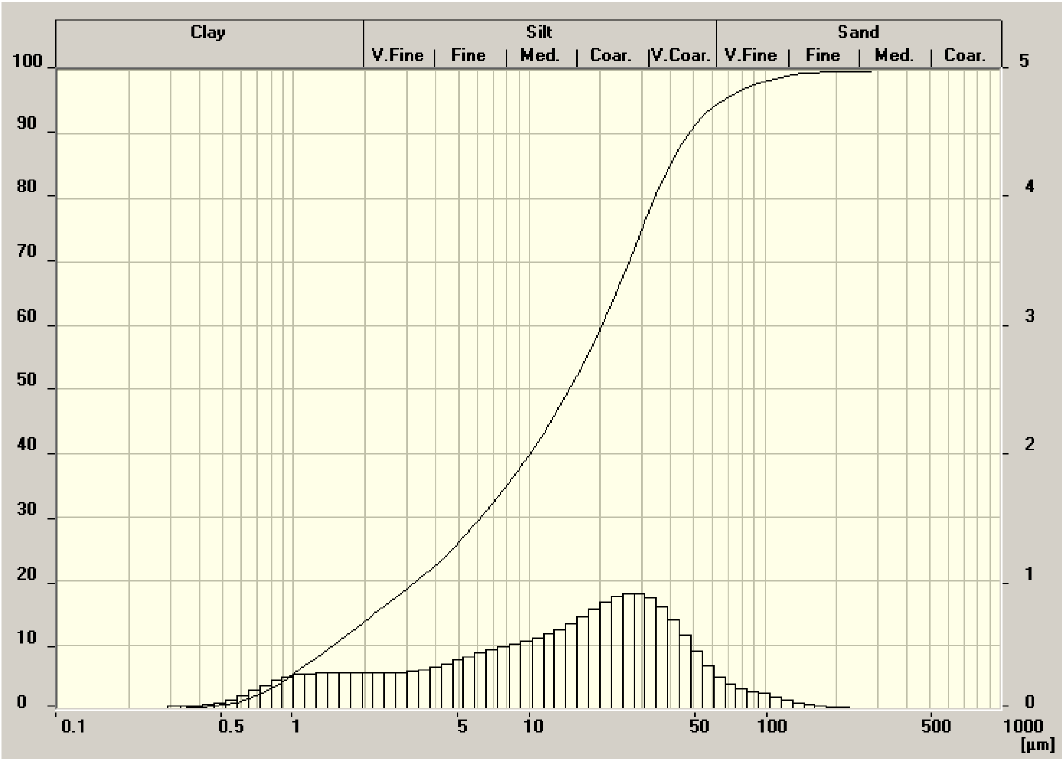

Figure IV-5: 12hrs Ball Milled Product - Sample 1

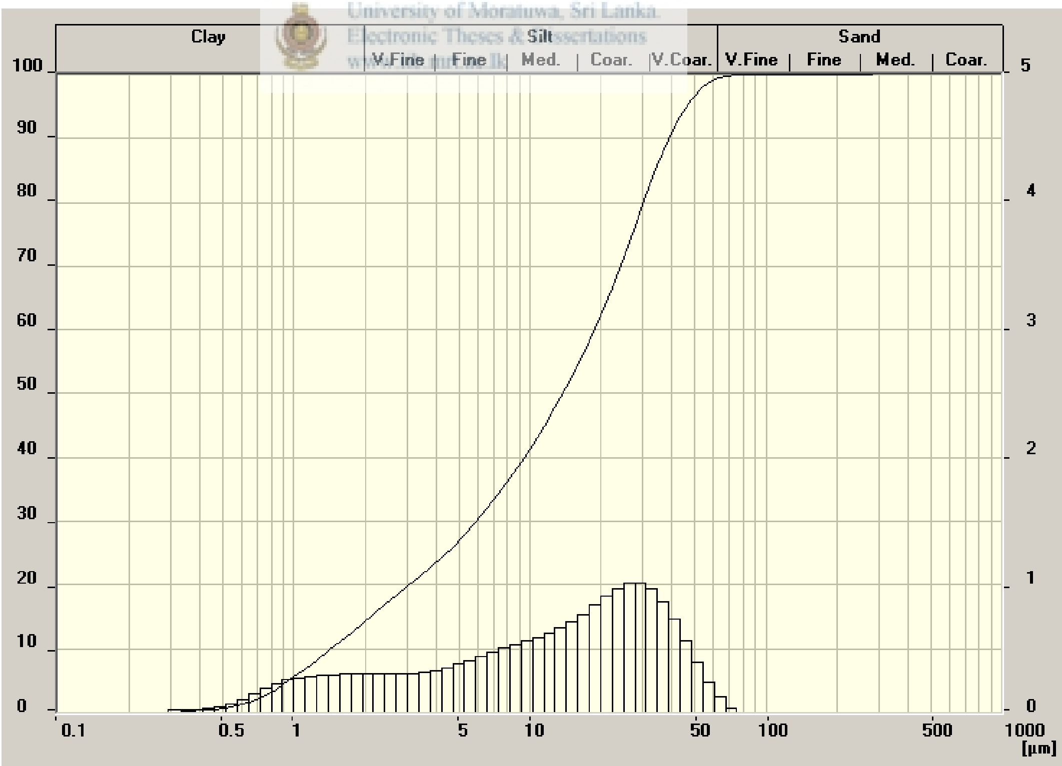

Figure IV-6: 12hrs Ball Milled Product - Sample 2

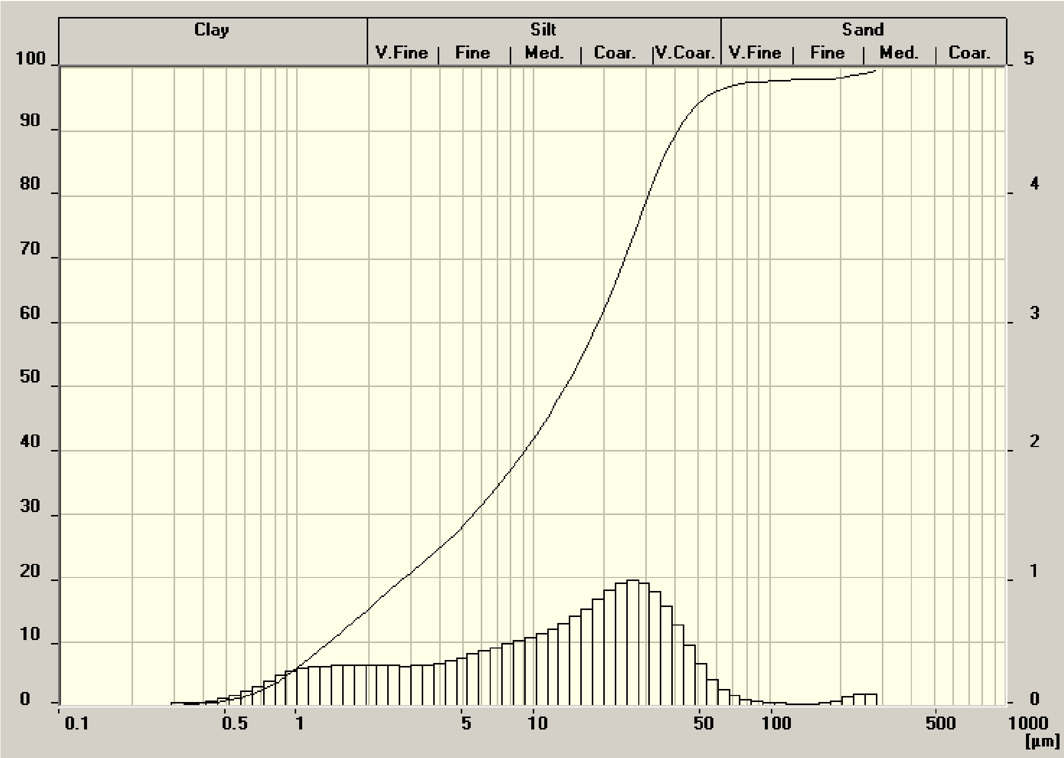

Figure IV-7: 16hrs Ball Milled Product - Sample 1

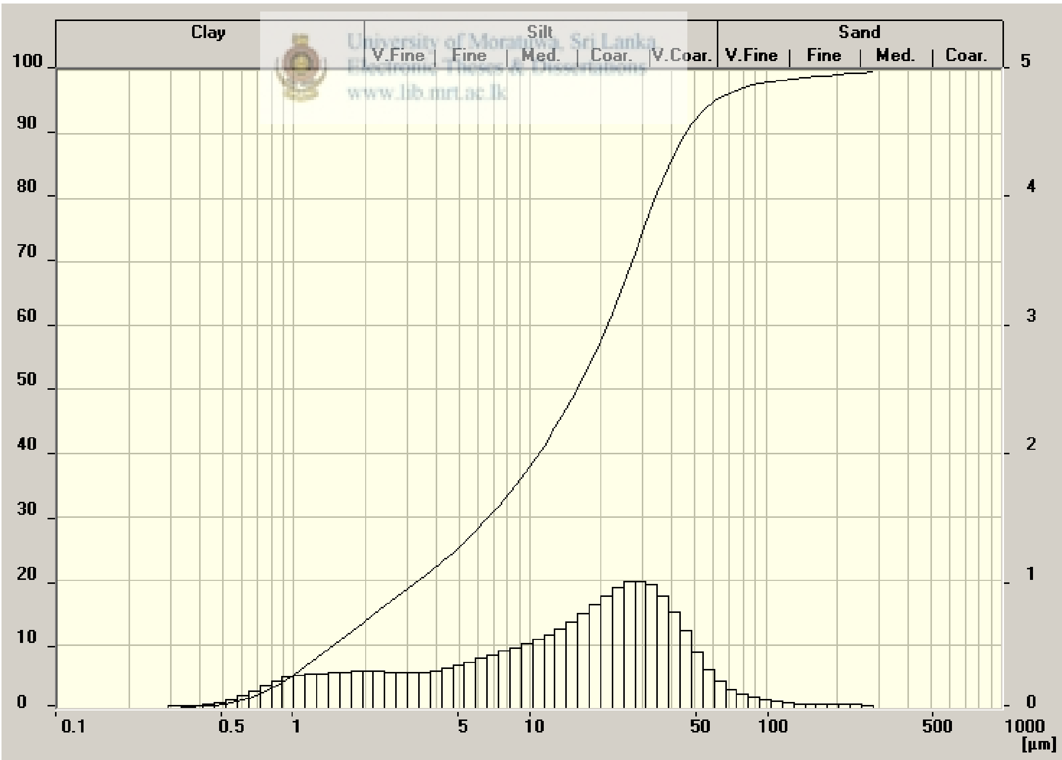

Figure IV-8: 16hrs Ball Milled Product - Sample 2

Appendix –V

Results of XRD Analysis

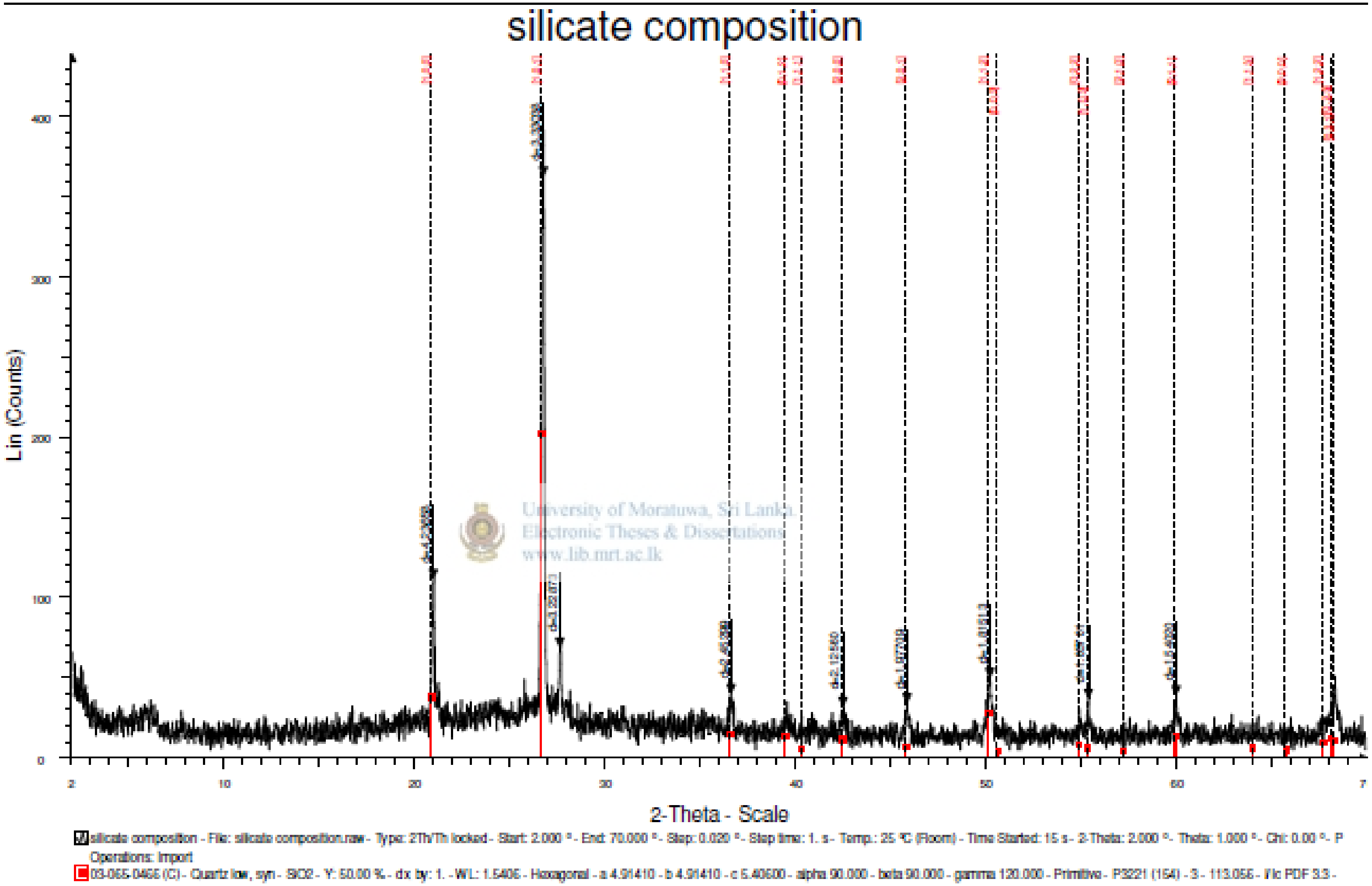

Figure V-1: XRD analysis results of 16hrs ball milled sample

FPM Results for Silicate

Sample name:	silicate composition
File name:	silicate composition.raw
Date of fitting:	20/07/2012 14:35:56
Fitting limits:	2.000 70.000
Number of steps:	20
R/R0:	1.22
RWP:	28.2
Delta displacement:	0.131 mm

03-065-0466	Quartz low, syn	
---------------------	SiO_2	
FWHM (30):	0.136 °	
Crystallite Size (Scherrer):	597.8 A	
System:	Hexagonal	
Space group:	P3221 (154)	
Cell parameter:	Initial Final	
a:	4.91410	Fixed
c:	5.40600	Fixed

Model Parameters:

Fitting limits:	3.000 60.000
Background degree:	3
Asymmetry [constant]:	0.999829
Asymmetry [/tan(th)^2]:	0.000419575
Asymmetry [/tan(th)^2]:	0.000117626
Broadening [*tan(th)]:	-0.191274
Broadening [*tan(th)^2]:	5.13099
Broadening [*tan(th)^3]:	0 Fixed
Lorentz width [Left const]:	1.15892
Lorentz width [Left/tan(th):	0.0133586
Lorentz width [Right const]:	-0.0360098
Lorentz width [Right/(tan(th)]:	0.242366

Appendix – VI

Cure Curves Obtained from the Rheometer Test

Figure VI-1: Cure curve of Compound 01 (sample 01)

Figure VI-2: Cure curve of Compound 02 (sample 02)

Figure VI-3: Cure curve of Compound 03 (sample 03)

Appendix - VII

Size Reduction Cost Calculation

Assumptions

1. Power consumption per unit product output in industrial-scale hammer milling and ball milling processes are similar to that of pilot-scale
2. Floor tile industry falls under Industrial –(I3) tariff category
3. Rejected tiles are processed during off peak time
4. Maximum demand is not influenced by this process

Table VII-1: Industrial purpose tariff plan of CEB

Tariff Category	Approved for 2011			
	Unit Charge [LKR/kWh]	Fuel Adjustment Charge [%]	Fixed Charge [LKR/month]	Demand Charge [LKR/kVA]
Industrial-(I1)	10.50	15	240.00	
Industrial-(I2)				
Peak	13.60	15	3000.00	850.00
Off peak	7.35	15		
Day	10.45	15		
Industrial-(I3)				
Peak	13.40	15	3000.00	750.00
Off peak	7.15	15		
Day	10.25	15		

Source - (CEB)

Based on the power meter readings obtained during hammer milling process (Appendix -II) and ball milling process (Appendix -III), average power consumption can be calculated as below.

Avg. power consumption during hammer milling process = 1.59 kW

Avg. power consumption during ball milling process = 1.05 kW

As per 3rd assumption, demand charge can be excluded. Thus only unit charge and the fuel adjustment charge should be calculated in this regard.

Table VII-2: Size reduction cost calculation

Process	Average Power Consumption [kW]	Milling Time [hr]	No. of Units [kWh]	Unit Charge [LKR/kg]	Fuel Adjustment Charge [LKR/kg]	Size Reduction Cost [LKR/kg]
Hammer Milling	1.59	0.053	0.1	0.12	0.02	**0.14**
Ball Milling	1.05	4	4.2	10.01	1.50	**11.51**
	1.05	8	8.4	20.02	3.00	**23.02**
	1.05	12	12.6	30.03	4.50	**34.53**
	1.05	16	16.8	40.04	6.01	**46.05**