

**STUDIES OF GEOPOLYMERIZATION ROUTE FOR
METAKAOLIN GEOPOLYMERIC MATERIALS**

LIEW YUN MING

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**STUDIES OF GEOPOLYMERIZATION
ROUTE FOR METAKAOLIN
GEOPOLYMERIC MATERIALS**

by

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A thesis submitted in fulfillment of the requirements for the
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DECLARATION OF THESIS

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TABLE OF CONTENT

	PAGE
THESIS DECLARATION	i
ACKNOWLEDGEMENT	ii
TABLE OF CONTENT	iii
LIST OF TABLES	ix
LIST OF FIGURES	xii
LIST OF ABBREVIATIONS	xx
ABSTRAK	xxii
ABSTRACT	xxiii
CHAPTER 1: INTRODUCTION	
1.1 Research Background	1
1.2 Problem Statement	6
1.3 Objectives of Study	7
CHAPTER 2: LITERATURE REVIEW	
2.1 Geopolymers	9
2.2 Terminology	10
2.3 Geopolymer Constituents	11
2.3.1 Source Materials	11
2.3.1.1 Treated Minerals	12
2.3.1.2 Waste Materials	15

2.3.1.3 Natural Minerals	17
2.3.2 Alkaline Activator Solution	17
2.4 Geopolymerization Mechanism	20
2.5 Structure of Geopolymers	27
2.5.1 Scanning Electron Microscope (SEM)	27
2.5.2 X-Ray Diffraction (XRD)	30
2.5.3 Fourier Transform Infrared Spectroscopy (FTIR)	34
2.6 Manufacturing of Geopolymers	37
2.7 Geopolymeric Powder	39
2.7.1 Importance of Geopolymeric Powder	39
2.8 Properties of Geopolymers	40
2.9 Factors Affecting the Properties of Geopolymers	43
2.9.1 Alkali Concentration	43
2.9.2 Solids-to-Liquid Ratios	45
2.9.3 Activator Ratios (Na_2SiO_3 -to- NaOH Ratio)	47
2.9.4 Water Content	49
2.9.5 Curing Regimes	49
2.10 Mixture Proportion	54

CHAPTER 3: METHODOLOGY

3.1 Materials	57
3.1.1 Metakaolin	57
3.1.2 Sodium Hydroxide (NaOH)	58
3.1.3 Sodium Silicate (Na_2SiO_3)	58
3.2 Preparation of Sodium Hydroxide (NaOH) Solution	59

3.3	Preparation of Alkaline Activator Solution	60
3.4	Preparation of Geopolymeric Powder	60
3.5	Preparation of Resulting Geopolymer Pastes	60
3.6	Details of Mixture Proportion	61
3.6.1	Effect of NaOH Concentrations	61
3.6.2	Effect of Solids-to-Liquid Ratios	64
3.6.3	Effect of Na ₂ SiO ₃ Solution/ NaOH Solution Ratios	64
3.6.4	Effect of Pre-curing Conditions	64
3.6.5	Effect of Percentage Mixing Water	65
3.6.6	Effect of Curing Regimes	65
3.7	Physical and Mechanical Properties and Characterization of Test Specimens	65
3.7.1	Workability Test	65
3.7.2	Setting Time Measurement	66
3.7.3	Bulk Density Measurement	66
3.7.4	Particle Size Distribution	67
3.7.5	Brunauer-Emmet-Teller (BET) Surface Area	67
3.7.6	X-ray Fluorescence (XRF)	67
3.7.7	Compressive Testing	68
3.7.8	Scanning Electron Microscope (SEM) / Energy Dispersive X-Ray Spectroscopy (EDX)	68
3.7.9	X-ray Diffraction (XRD)	68
3.7.10	Fourier Transform Infrared Spectroscopy (FTIR)	69
3.8	Experimental Flow Chart	69

CHAPTER 4: RESULTS AND DISCUSSION

4.1	Characterization of Metakaolin	71
4.1.1	X-ray Fluorescence (XRF)	71
4.1.2	Particle Size Distribution (PSD) and Branauer-Emmett-Teller (BET) Surface Area	72
4.1.3	Scanning Electron Microscopy (SEM) and Energy Dispersive X-ray (EDX) Spectroscopy	73
4.1.4	X-ray Diffraction (XRD)	76
4.1.5	Fourier Transform Infrared Spectroscopy (FTIR)	77
4.2	Effect of NaOH Concentrations	79
4.2.1	Workability	79
4.2.2	Bulk Density	80
4.2.3	Compressive Strength	82
4.2.4	Scanning Electron Microscopy (SEM)	83
4.2.5	X-ray Diffraction (XRD)	86
4.2.6	Fourier Transform Infrared Spectroscopy (FTIR)	89
4.3	Effect of Solids-to-Liquid Ratios	93
4.3.1	Workability	93
4.3.2	Bulk Density	95
4.3.3	Compressive Strength	96
4.3.4	Scanning Electron Microscopy (SEM)	97
4.3.5	X-ray Diffraction (XRD)	99
4.3.6	Fourier Transform Infrared Spectroscopy (FTIR)	102
4.4	Effect of Activator Ratios	105
4.4.1	Workability	105
4.4.2	Bulk Density	107

4.4.3 Compressive Strength	107
4.4.4 Scanning Electron Microscopy (SEM)	109
4.4.5 X-ray Diffraction (XRD)	111
4.4.6 Fourier Transform Infrared Spectroscopy (FTIR)	113
4.5 Effect of Pre-curing Conditions	117
4.5.1 Setting Time	117
4.5.2 Bulk Density	118
4.5.3 Compressive Strength	119
4.5.4 Scanning Electron Microscopy (SEM)	121
4.5.5 X-ray Diffraction (XRD)	127
4.5.6 Fourier Transform Infrared Spectroscopy (FTIR)	132
4.6 Effect of Percentage Mixing Water	137
4.6.1 Workability	137
4.6.2 Setting Time	138
4.6.3 Bulk Density	139
4.6.4 Compressive Strength	140
4.6.5 Scanning Electron Microscopy (SEM)	142
4.6.6 X-ray Diffraction (XRD)	144
4.6.7 Fourier Transform Infrared Spectroscopy (FTIR)	145
4.7 Effect of Curing Regimes	147
4.7.1 Setting Time	147
4.7.2 Bulk Density	149
4.7.3 Compressive Strength	151
4.7.4 Scanning Electron Microscopy (SEM)	155
4.7.5 X-ray Diffraction (XRD)	160

4.7.6 Fourier Transform Infrared Spectroscopy (FTIR)	162
4.8 Effect of Oxide-molar Ratios on Compressive Strength	166
CHAPTER 5: CONCLUSIONS AND SUGGESTIONS	
5.1 Conclusions	172
5.2 Suggestions	174
REFERENCES	175
APPENDICES	
Appendix A: Calculation Methods of Mixture Proportions	186
Appendix C: List of Publications	187
Appendix D: List of Exhibition and Awards	190

LIST OF TABLES

NO.		PAGE
Table 1.1	Summary of important historical development of geopolymers	1
Table 2.1	The Si/Al and Na/Al ratios of fly ash geopolymers at Point 9 to 14 (Fernandez-Jimenez & Palomo, 2005a)	29
Table 2.2	Composition ranges of geopolymer mixture, in term of oxide molar ratios (Davidovits, 1982)	54
Table 3.1	Properties of kaolin (AKIMA-45)	57
Table 3.2	Properties of sodium hydroxide (NaOH)	58
Table 3.3	Specification of sodium silicate (Na_2SiO_3) solution	59
Table 3.4	Details of mixture proportion	62
Table 4.1	Elemental oxide composition of kaolin and metakaolin, as determined by XRF analysis	71
Table 4.2	Mass percentage of elements in kaolin and metakaolin, as determined by EDX analysis	75
Table 4.3	Summary assignments of FTIR absorption bands in kaolin and metakaolin	79
Table 4.4	Summary assignments of absorption bands in geopolymeric powder and resulting pastes with various NaOH concentrations	93
Table 4.5	Peak height, in percentage transmittance, for Si–O–Al/Si–O–Si bonds in geopolymeric powder and resulting pastes with various NaOH concentrations	93
Table 4.6	Assignments of absorption bands in geopolymeric powder and resulting pastes with various solids/liquid ratios	105
Table 4.7	Peak height, in percentage transmittance, for Si–O–Al/Si–O–Si bonds in geopolymeric powder and resulting pastes with various solids/liquid ratios	105
Table 4.8	Assignments of absorption bands in geopolymeric powder and resulting pastes with various activator ratios	116

Table 4.9	Comparison peak height for Si–O–Al/Si–O–Si bonds in geopolymeric powder and resulting paste with various activator ratios	116
Table 4.10	Summary initial and final setting times of geopolymer mixtures at various pre-curing temperatures	118
Table 4.11	Bulk densities of resulting geopolymer pastes synthesized from geopolymeric powder pre-cured at various pre-curing conditions after 7 days	119
Table 4.12	Compressive strength of resulting pastes synthesized using various pre-curing conditions after 7 days	120
Table 4.13	Mass percentage of elements in geopolymeric powder (Pre-cured at 80 °C for 4 hours) at Point 1 and 2, as obtained from EDX analysis	126
Table 4.14	Comparison Na, Si and Al contents, Si/Al and Na/Al ratios in metakaolin and geopolymeric powder	127
Table 4.15	Assignments of absorption bands in geopolymeric powder synthesized at various pre-curing temperatures and times	136
Table 4.16	Assignments of absorption bands in resulting pastes synthesized at various pre-curing temperatures and times	136
Table 4.17	Comparison peak height for Si–O–Al/Si–O–Si bonds in geopolymeric powder pre-cured at various pre-curing conditions and the resulting pastes	137
Table 4.18	Summary initial and final setting times of resulting geopolymer pastes at various percentages of mixing water	139
Table 4.19	Assignments of absorption bands in resulting pastes with various percentages of mixing water	147
Table 4.20	Comparison peak height for Si–O–Al/Si–O–Si bonds resulting paste with various percentages of mixing water	147
Table 4.21	Summary initial and final setting times of resulting geopolymer pastes at various curing temperatures	149
Table 4.22	Mass percentage of elements at Point 1, as obtained from EDX analysis, for resulting paste cured at 60 °C for 72 hours after 28 days	159
Table 4.23	Comparison Na, Si and Al contents, Si/Al and Na/Al ratios in geopolymeric powder and resulting paste	160
Table 4.24	Assignments of absorption bands in resulting geopolymers paste cured at various curing temperatures and times	165

Table 4.25	Comparison peak height for Si–O–Al/Si–O–Si bonds resulting pastes cured at various curing regimes	166
Table 4.26	Summary of SiO ₂ /Al ₂ O ₃ , Na ₂ O/SiO ₂ , H ₂ O/Na ₂ O and Na ₂ O/Al ₂ O molar ratios at various NaOH concentrations, solids/liquid and Na ₂ SiO ₃ /NaOH ratios	167

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LIST OF FIGURES

NO.		PAGE
Figure 2.1	Classification of geopolymers (Davidovits, 1991)	11
Figure 2.2	Compressive strength of geopolymers activated with (a) NaOH solution and (b) alkaline sodium silicate at 75 °C for 24 hours (KA, WC, GC and RC represented calcined pure kaolin, white clay, grey clay and red clay at 700 °C for 2 hours) (Mohsen & Mostafa, 2010)	19
Figure 2.3	Schematic diagram of geopolymerization process (Davidovits, 1994a, 1994b)	21
Figure 2.4	Role of water in geopolymerization (Zuhua et al., 2009)	22
Figure 2.5	Model of processes occurred during geopolymerization process (Provis et al., 2006)	23
Figure 2.6	Graphic model of alkali activation of geopolymers (Duxson et al., 2007)	25
Figure 2.7	Sketch of geopolymerization process (Xiao et al., 2009)	26
Figure 2.8	SEM micrographs of metakaolin geopolymers at magnification of (a) 1500× and (b) 10000× (Wang et al., 2005)	27
Figure 2.9	ESEM micrographs of metakaolin geopolymers at the same area after (a) 10 minutes; (b) 3 hours; (c) 6 hours; and (d) 9 hours after mixing at ×3200 magnification (Zhang et al., 2005)	28
Figure 2.10	SEM micrographs showing (a) un-reacted fly ash; (b) surface cracking and (c) aggregate-matrix interface of fly ash geopolymers activated with NaOH and sodium silicate solutions (Fernandez-Jimenez & Palomo, 2005a)	29
Figure 2.11	X-ray diffractograms for poly (sialate-silixo) binder with SiO ₂ /Al ₂ O ₃ molar ratios of (a) 4.02; (b) 3.98; (c) 3.39 and (d) 4.11 (Davidovits, 1994d)	30
Figure 2.12	XRD pattern of metakaolin geopolymers at different curing temperatures (SC = steam curing and AC = air curing) (Xiao et al., 2009)	31

Figure 2.13	XRD patterns of geopolymers from Algerian metakaolin, activated with alkaline sodium silicate solution and cured at 50 °C for 24 h with various Si/Al ratios (Zibouche et al., 2009)	32
Figure 2.14	XRD pattern of metakaolin geopolymers at 7, 28 and 90 days (• denoted zeolite peaks) (Duxson et al., 2007)	33
Figure 2.15	FTIR spectra of Gel 1 (G1) and Gel 2 (G2) (Criado et al., 2007)	35
Figure 2.16	IR spectra of slag and slag geopolymers synthesized at various curing conditions (Komnitsas et al., 2007)	36
Figure 2.17	FTIR spectra of fly ash and bottom ash geopolymers at various NaOH concentrations (FA – Fly ash and BT – Bottom Ash) (Chindaprasirt et al., 2009)	37
Figure 2.18	Compressive strength of metakaolin geopolymers under different curing conditions (Zuhua et al., 2009)	51
Figure 3.1	General experimental flow chart	70
Figure 4.1	Particle size distribution of kaolin and metakaolin	72
Figure 4.2	SEM micrograph of (a) kaolin and (b) metakaolin at $\times 2000$ magnification	73
Figure 4.3	EDX spectrum of kaolin	74
Figure 4.4	EDX spectrum of metakaolin	75
Figure 4.5	XRD diffractogram of kaolin and metakaolin	77
Figure 4.6	FTIR spectrum of kaolin and metakaolin	78
Figure 4.7	Mini-slump values of geopolymer mixtures at various NaOH concentrations	80
Figure 4.8	Bulk densities of resulting pastes with various NaOH concentrations after 7 days	81
Figure 4.9	Compressive strength of resulting pastes after 7 days at various NaOH concentrations	83
Figure 4.10	SEM micrographs of (a) geopolymeric powder and (b) resulting paste synthesized using 6M of NaOH solution (MK – Plate structure and GP – Spherical geopolymer aggregates)	84
Figure 4.11	SEM micrographs of (a) geopolymeric powder and (b) resulting paste synthesized using 8M of NaOH solution (MK – Plate structure and GP – Spherical geopolymer aggregates)	85

Figure 4.12	SEM micrographs of (a) geopolymeric powder and (b) resulting paste synthesized using 12M of NaOH solution (MK – Plate structure and GP – Spherical geopolymer aggregates)	86
Figure 4.13	XRD diffractograms of geopolymeric powder and resulting paste synthesized using 6M of NaOH solution	87
Figure 4.14	XRD diffractograms of geopolymeric powder and resulting paste synthesized using 8M of NaOH solution	88
Figure 4.15	XRD diffractograms of geopolymeric powder and resulting paste synthesized using 12M of NaOH solution	89
Figure 4.16	FTIR spectra of geopolymeric powder and resulting paste synthesized using 6M of NaOH solution	91
Figure 4.17	FTIR spectra of geopolymeric powder and resulting paste synthesized using 8M of NaOH solution	92
Figure 4.18	FTIR spectra of geopolymeric powder and resulting paste synthesized using 12M of NaOH solution	92
Figure 4.19	Mini-slump values for geopolymer mixtures with various solids/liquid ratios	94
Figure 4.20	Bulk densities of resulting geopolymer pastes with various solids/liquid ratios after 7 days	95
Figure 4.21	Compressive strength of resulting pastes with various solids/liquid ratios after 7 days	97
Figure 4.22	SEM micrographs of (a) geopolymeric powder and (b) resulting paste with solids/liquid ratio of 0.60 (MK – Plate structure and GP – Spherical geopolymer aggregates)	98
Figure 4.23	SEM micrographs of (a) geopolymeric powder and (b) resulting paste with solids/liquid ratio of 0.80 (MK – Plate structure and GP – Spherical geopolymer aggregates)	99
Figure 4.24	SEM micrographs of (a) geopolymeric powder and (b) resulting paste with solids/liquid ratio of 1.00 (MK – Plate structure and GP – Spherical geopolymer aggregates)	99
Figure 4.25	XRD diffractograms of geopolymeric powder and resulting paste with solids/liquid ratio of 0.60	101
Figure 4.26	XRD diffractograms of geopolymeric powder and resulting paste with solids/liquid ratio of 0.80	101
Figure 4.27	XRD diffractograms of geopolymeric powder and resulting paste with solids/liquid ratio of 1.00	102

Figure 4.28	FTIR spectra of geopolymeric powder and resulting paste with solids/liquid ratio of 0.60	103
Figure 4.29	FTIR spectra of geopolymeric powder and resulting paste with solids/liquid ratio of 0.80	104
Figure 4.30	FTIR spectra of geopolymeric powder and resulting paste with solids/liquid ratio of 1.00	104
Figure 4.31	Mini-slump values of geopolymer mixtures with various activator ratios	106
Figure 4.32	Bulk densities of resulting pastes with various activator ratios after 7 days	107
Figure 4.33	Compressive strength of resulting pastes with various activator ratios after 7 days	109
Figure 4.34	SEM micrographs of (a) geopolymeric powder and (b) resulting geopolymer paste synthesized using an activator ratio of 0.12 (MK – Plate structure and GP – Spherical geopolymer aggregates)	110
Figure 4.35	SEM micrographs of (a) geopolymeric powder and (b) resulting geopolymer paste synthesized using an activator ratio of 0.20 (MK – Plate structure and GP – Spherical geopolymer aggregates)	110
Figure 4.36	SEM micrographs of (a) geopolymeric powder and (b) resulting geopolymer paste synthesized using an activator ratio of 0.28 (MK – Plate structure and GP – Spherical geopolymer aggregates)	111
Figure 4.37	XRD diffractograms of geopolymeric powder and the resulting paste synthesized using an activator ratio of 0.12	112
Figure 4.38	XRD diffractograms of geopolymeric powder and the resulting paste synthesized using an activator ratio of 0.20	112
Figure 4.39	XRD diffractograms of geopolymeric powder and the resulting paste synthesized using an activator ratio of 0.28	113
Figure 4.40	FTIR spectra of geopolymeric powder and the resulting paste synthesized with an activator ratio of 0.12	114
Figure 4.41	FTIR spectra of geopolymeric powder and the resulting paste synthesized with an activator ratio of 0.20	115
Figure 4.42	FTIR spectra of geopolymeric powder and the resulting paste synthesized with an activator ratio of 0.28	115

Figure 4.43	Setting time measurement of mixtures synthesized at various pre-curing temperatures	117
Figure 4.44	SEM micrographs of (a) geopolymeric powder and (b) resulting geopolymer paste pre-cured at 40 °C for 7 hours (MK – Plate structure and GP – Spherical geopolymer aggregates)	122
Figure 4.45	SEM micrographs of (a) geopolymeric powder and (b) resulting geopolymer paste pre-cured at 60 °C for 5 hours (MK – Plate structure and GP – Spherical geopolymer aggregates)	122
Figure 4.46	SEM micrographs of (a) geopolymeric powder and (b) resulting geopolymer paste pre-cured at 80 °C for 3 hours (MK – Plate structure and GP – Spherical geopolymer aggregates)	123
Figure 4.47	SEM micrographs of (a) geopolymeric powder and (b) resulting geopolymer paste pre-cured at 80 °C for 4 hours (MK – Plate structure and GP – Spherical geopolymer aggregates)	123
Figure 4.48	SEM micrographs of (a) geopolymeric powder and (b) resulting geopolymer paste at pre-curing condition of 80 °C for 6 hours (MK – Plate structure and GP – Spherical geopolymer aggregates)	124
Figure 4.49	SEM micrographs of (a) geopolymeric powder and (b) resulting geopolymer paste at pre-curing condition of 100 °C for 2 hours (MK – Plate structure and GP – Spherical geopolymer aggregates)	124
Figure 4.50	EDX spectrum of geopolymeric powder (Pre-cured at 80 °C for 4 hours) at Point 1 (Un-reacted metakaolin)	125
Figure 4.51	EDX spectrum of geopolymeric powder (Pre-cured at 80 °C for 4 hours) at Point 2 (Activated metakaolin)	126
Figure 4.52	XRD diffractograms of geopolymeric powder pre-cured at 40 °C for 7 hours and the resulting geopolymer paste	128
Figure 4.53	XRD diffractograms of geopolymeric powder pre-cured at 60 °C for 5 hours and the resulting geopolymer paste	129
Figure 4.54	XRD diffractograms of geopolymeric powder pre-cured at 80 °C for 3 hours and the resulting geopolymer paste	130
Figure 4.55	XRD diffractograms of geopolymeric powder pre-cured at 80 °C for 4 hours and the resulting geopolymer paste	130

Figure 4.56	XRD diffractograms of geopolymetric powder pre-cured at 80 °C for 6 hours and the resulting geopolymer paste	131
Figure 4.57	XRD diffractograms of geopolymetric powder pre-cured at 100 °C for 2 hours and the resulting geopolymer paste	131
Figure 4.58	FTIR spectra of geopolymetric powder pre-cured at 40 °C for 7 hours and the resulting geopolymer paste	133
Figure 4.59	FTIR spectra of geopolymetric powder pre-cured at 60 °C for 5 hours and the resulting geopolymer paste	133
Figure 4.60	FTIR spectra of geopolymetric powder pre-cured at 80 °C for 3 hours and the resulting geopolymer paste	134
Figure 4.61	FTIR spectra of geopolymetric powder pre-cured at 80 °C for 4 hours and the resulting geopolymer paste	134
Figure 4.62	FTIR spectra of geopolymetric powder pre-cured at 80 °C for 6 hours and the resulting geopolymer paste	135
Figure 4.63	FTIR spectra of geopolymetric powder pre-cured at 100 °C for 2 hours and the resulting geopolymer paste	135
Figure 4.64	Mini-slump values of mixtures with various percentages of mixing water	138
Figure 4.65	Setting time measurement of resulting geopolymer pastes at various percentages of mixing water	139
Figure 4.66	Bulk densities of resulting geopolymer pastes produced with various percentages of mixing water after 7 days	140
Figure 4.67	Compressive strength of resulting geopolymer pastes at various percentages of mixing water after 7 days	141
Figure 4.68	SEM micrographs of resulting geopolymer paste produced with (a) 16%; (b) 18%; (c) 20%; (d) 22% and (e) 24% of mixing water (MK – Plate structure and GP – Spherical geopolymer aggregates)	143
Figure 4.69	XRD diffractograms of resulting geopolymer paste with various percentages of mixing water	144
Figure 4.70	FTIR spectra of resulting geopolymer pastes with various percentages of mixing water	146
Figure 4.71	Setting time measurement of resulting geopolymer pastes at various curing temperatures	148

Figure 4.72	Bulk densities of resulting geopolymer pastes cured at 40 °C, 60 °C, 80 °C and 100 °C after 7 days	150
Figure 4.73	Bulk densities of resulting geopolymer pastes cured at 40 °C, 60 °C, 80 °C and 100 °C after 28 days	151
Figure 4.74	Compressive strength of resulting geopolymer paste cured at 40 °C for various curing times (6h, 12h, 24h, 48h and 72h) after 1, 3, 7 and 28 days	152
Figure 4.75	Compressive strength of resulting geopolymer paste cured at 60 °C for various curing times (6h, 12h, 24h, 48h and 72h) after 1, 3, 7 and 28 days	153
Figure 4.76	Compressive strength of resulting geopolymer paste cured at 80 °C for various curing times (6h, 12h, 24h, 48h and 72h) after 1, 3, 7 and 28 days	154
Figure 4.77	Compressive strength of resulting geopolymer paste cured at 100 °C for various curing times (6h, 12h, 24h, 48h and 72h) after 1, 3, 7 and 28 days	155
Figure 4.78	SEM micrograph of resulting geopolymer paste cured at (a) room temperature (29 °C); (b) 40 °C for 72 hours; (c) 80 °C for 72 hours; and (d) 100 °C for 72 hours for 28 days (MK – Plate structure and GP – Spherical geopolymer aggregates)	157
Figure 4.79	SEM micrographs of resulting geopolymer paste cured at 60 °C for 72 hours after (a) 1 day; (b) 3 days; (c) 7 days and (d) 28 days (MK – Plate structure and GP – Spherical geopolymer aggregates)	158
Figure 4.80	EDX spectrum at Point 1 for resulting paste cured at 60 °C for 72 hours after 28 days	159
Figure 4.81	XRD diffractograms of resulting geopolymer pastes cured at 60 °C for 72 hours after 1, 3, 7 and 28 days	161
Figure 4.82	XRD diffractograms of resulting geopolymer pastes at various curing temperatures after 28 days	162
Figure 4.83	FTIR spectra of resulting geopolymer pastes cured at 60 °C for 72 hours after 1, 3, 7 and 28 days	163
Figure 4.84	FTIR spectra of resulting geopolymer pastes cured at various curing regimes after 28 days	164
Figure 4.85	Changes in oxide-molar ratios with NaOH concentrations	168
Figure 4.86	Changes in oxide-molar ratios with S/L ratios	168

Figure 4.87	Changes in oxide-molar ratios with activator ratios	169
Figure 4.88	Proposed chemical attack on geopolymeric powder to form resulting pastes	171

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LIST OF ABBREVIATIONS

Al	Aluminium
Al ₂ O ₃	Alumina
aq	Aqueous
BET	Branauer-Emmett-Teller
Ca	Calcium
Cr	Chromium
CSH	Calcium Silicate Hydrated
d	Day
EDX	Energy Dispersive X-ray Spectroscopy
Fe ₂ O ₃	Iron (III) Oxide
FTIR	Fourier Transform Infrared Spectroscopy
GGBFS	Ground-granulated Blast Furnace Slag
h	hour
HCl	Hydrochloric acid
H ₂ O	Dihydrogen Monoxide
H ₂ SO ₄	Sulphuric Acid
KOH	Potassium Hydroxide
K ₂ SiO ₃	Potassium Silicate
LOI	Lost of Ignition
Mn	Manganese

MnO ₂	Manganese Dioxide
Mg	Magnesium
Na	Sodium
Na ₂ SiO ₃	Sodium Silicate
Na ₂ O	Sodium Oxide
K	Potassium
K ₂ O	Potassium Oxide
NaOH	Sodium Hydroxide
OH ⁻	Hydroxyl Ion
P	Phosphorus
PSD	Particle Size Distribution
S/L	Solids-to-liquid Ratio
S	Sulphur
s	solid
SiO ₂	Silica
Si	Silicon
SEM	Scanning Electron Microscope
TiO ₂	Titanium Dioxide
XRD	X-ray Diffraction
XRF	X-Ray Fluorescence
ZrO ₂	Zirconium Dioxide
°C	Degree Celsius

Kajian Tentang Laluan Penggeopolimeran Untuk Bahan-bahan Geopolimer Metakaolin

ABSTRAK

Kajian tentang penghasilan serbuk geopolimer metakaolin adalah bertujuan untuk meningkatkan produktiviti dan penggunaan produk geopolimer. Proses penggeopolimeran telah diaplikasikan dalam penghasilan serbuk geopolimer untuk sintesis pes geopolimer. Lumpur geopolimer dihasilkan melalui proses pengaktifan metakaolin dalam larutan pengaktif beralkali (campuran larutan NaOH dan natrium silikat). Lumpur geopolimer yang dihasilkan dimasukkan dalam ketuhar untuk memperolehi pes pepejal dan seterusnya dikisarkan kepada serbuk bersaiz seragam. Melalui konsep “hanya menambah air”, serbuk geopolimer dicampurkan dengan air dan diawetkan dalam ketuhar untuk menghasilkan pes geopolimer. Sifat-sifat fizikal dan mekanikal serbuk dan pes geopolimer termasuk keboleherjaan, tempoh pengesetan, ketumpatan pukal dan kekuatan mampatan telah dikaji. Selain itu, analisis SEM/EDX, XRD dan FTIR telah dijalankan. Keputusan menunjukkan bahawa keadaan optima untuk penghasilan serbuk dan pes geopolimer yang berkekuatan tinggi adalah dengan menggunakan larutan NaOH 8M, nisbah pepejal/cecair 0.80, nisbah larutan pengaktif 0.20, keadaan pemejalan pada suhu 80 °C selama 4 jam, 22% campuran air dan proses pengawetan yang dijalankan pada suhu 60 °C selama 72 jam. Pes geopolimer yang dihasilkan mempunyai ketumpatan pukal yang rendah dan berpotensi untuk dijadikan sebagai bahan ringan. Pencampuran serbuk geopolimer dengan air menyebabkan ketumpatan struktur dengan pembentukan gel geopolimer yang lebih padat. Serbuk dan pes geopolimer turut menunjukkan kombinasi fasa-fasa amorfus dan hablur apabila dikaji dengan analisis XRD. Intensiti fasa zeolit semakin meningkat dengan peningkatan penuaan dan ini menekankan manfaat zeolit dalam peningkatan kekuatan mampatan pes geopolimer yang dihasilkan. Di samping itu, analisis FTIR menunjukkan pembentukan ikatan geopolimer dalam struktur. Nisbah molar $\text{SiO}_2/\text{Al}_2\text{O}_3$, $\text{Na}_2\text{O}/\text{SiO}_2$, $\text{H}_2\text{O}/\text{Na}_2\text{O}$ dan $\text{Na}_2\text{O}/\text{Al}_2\text{O}_3$ yang optima adalah 3.10, 0.37, 14.23 dan 1.15. Kajian atas nisbah molar oksida menyimpulkan bahawa nisbah molar $\text{Na}_2\text{O}/\text{Al}_2\text{O}_3$ dan $\text{H}_2\text{O}/\text{Na}_2\text{O}$ memberi kesan yang tinggi kepada sifat mekanikal pes geopolimer. Hasil kajian ini jelas membuktikan bahawa penghasilan serbuk geopolimer metakaolin ini boleh digunakan dalam sintesis pes geopolimer.