

TABLE OF CONTENTS

	Page
ABSTRACT (THAI).....	I
ABSTRACT (ENGLISH).....	III
ACKNOWLEDGEMENT.....	V
TABLE OF CONTENTS.....	VI
LIST OF TABLES.....	IX
LIST OF FIGURES.....	X
SYMBOLS AND ABBREVIATIONS.....	XII
CHAPTER	
1 INTRODUCTION.....	1
1.1 General background.....	1
1.2 Research objectives.....	2
1.3 Scope and limitation of the study.....	3
2 LITERATURE REVIEWS.....	4
2.1 Polymer-modified mortar.....	4
2.2 Effect of the addition of polymer latex in mortar.....	7
2.2.1 Synthetic polymer.....	7
2.2.2 Natural polymer.....	8
2.3 Effect of the addition of silica in mortar.....	11
2.4 Preparation of silica from rice husk ash.....	13
3 RESEARCH METHODOLOGY.....	16
3.1 Materials.....	16
3.2 Experimental.....	16
3.2.1 Preparation of RSi and CSi.....	16
3.2.1.1 Extraction of rice husk sodium silicate.....	16

TABLE OF CONTENTS (Continued)

	Page
3.2.1.2 Precipitation of RSi and CSi.....	17
3.2.2 Characterization of RSi and CSi.....	17
3.2.2.1 Fourier transform infrared spectrometer.....	17
3.2.2.2 Energy dispersive X-ray florescence spectrometer.....	17
3.2.2.3 X-ray diffractometer.....	17
3.2.2.4 Branauer-Emmett-Teller analysis.....	17
3.2.2.5 Dynamic light scattering measurement.....	18
3.2.2.6 Field emission scanning electron microscope.....	18
3.2.3 Preparation of rubber composite.....	18
3.2.3.1 Mixing and drying of rubber sheet.....	18
3.2.3.2 Compounding and vulcanizing of rubber composite.....	19
3.2.4 Characterization of rubber composite.....	19
3.2.4.1 Cure characteristics.....	19
3.2.4.2 Mechanical properties.....	19
3.2.4.3 Morphological properties.....	20
3.2.5 Preparation of polymer-modified mortar.....	20
3.2.6 Characterization of polymer-modified mortar.....	22
3.2.6.1 Mechanical properties.....	22
3.2.6.2 Water absorption.....	23
3.2.6.3 Morphological properties.....	24
4 RESULTS AND DISCUSSION.....	25
4.1 Characterization of RSi and CSi.....	25
4.1.1 Fourier transform infrared spectrometer.....	25
4.1.2 Energy dispersive X-ray florescence spectrometer.....	26
4.1.3 X-ray diffractometer.....	26
4.1.4 Branauer-Emmett-Teller analysis.....	27

TABLE OF CONTENTS (Continued)

	Page
4.1.5 Dynamic light scattering measurement.....	28
4.1.6 Field emission scanning electron microscope.....	29
4.2 Effect of RSi content on properties of NR/RSi composites.....	30
4.2.1 Cure characteristics.....	30
4.2.2 Mechanical properties.....	32
4.2.3 Morphological properties.....	34
4.3 Effect of RSi content on properties of NR/VTES/RSi composites	35
4.3.1 Cure characteristics.....	37
4.3.2 Mechanical properties.....	38
4.3.3 Morphological properties.....	41
4.4 Effect of RSi content on properties of NR/XSBR/RSi composites.....	42
4.4.1 Cure characteristics.....	44
4.4.2 Mechanical properties	46
4.4.3 Morphological properties.....	48
4.5 Effect of polymer content on properties of PMM.....	49
4.5.1 Mechanical properties.....	50
4.5.2 Water absorption.....	52
4.5.3 Morphological properties.....	53
5 CONCLUSION AND RECOMMENDATION.....	56
REFERENCES.....	57
APPENDIX A.....	65
APPENDIX B.....	69
BIOGRAPHY.....	84

LIST OF TABLES

Table		Page
2.1	Quality requirements of PMM in JIS A 6203.....	5
3.1	Rubber compounding chemicals.....	19
3.2	Sample codes and mix proportions of PMM.....	21
4.1	Chemical compositions of RSi and CSi.....	26
4.2	BET surface are, total pore volume, and average pore diameter of RSi and CSi.....	28
4.3	Average particle sizes of RSi and CSi.....	29
4.4	Cure characteristics of NR and NR/RSi composites.....	31
4.5	Mechanical properties of NR and NR/RSi composites.....	33
4.6	Mechanical properties of NR/5RSi and NR/VTES/5RSi composites.....	36
4.7	Cure characteristics of NR and NR/VTES/RSi composites.....	38
4.8	Mechanical properties of NR and NR/VTES/RSi composites.....	40
4.9	Mechanical properties of NR, XSBR, and their blends.....	43
4.10	Cure characteristics of 2NR/XSBR and 2NR/XSBR/RSi composites.....	45
4.11	Mechanical properties of 2NR/XSBR and 2NR/XSBR/RSi composites.....	47
4.12	Mechanical properties of NR and rubber composites.....	50
4.13	Mechanical properties of unadded PMM and PMM.....	50
4.14	Water absorption of unadded PMM and PMM.....	52

LIST OF FIGURES

Figure	Page
2.1	Physical model of PMM when the force in flexural mode is applied.....4
2.2	Schematic diagram of PMM preparation procedures.....6
2.3	NR particle models.....9
2.4	Chemical structure of cis-1,4-polyisoprene.....9
2.5	Chemical structure of VTES.....14
2.6	Chemical structure of XSBR.....15
3.1	Dimensions of the type C test specimen according to ASTM D412.....20
3.2	Curing of the test specimens.....21
3.3	Dimensions of the briquette-shape test specimen according to ASTM C190.....22
4.1	FTIR spectra of RSi and CSi.....25
4.2	XRD diffractograms of RSi and CSi.....27
4.3	Physisorption isotherms of RSi and CSi.....28
4.4	Particle size distributions of RSi and CSi.....29
4.5	FESEM images of RSi and CSi.....30
4.6	Cure characteristics of NR and NR/RSi composites showing (a) ML and MH and (b) t ₂ and t _{c90}31
4.7	Mechanical properties of NR and NR/RSi composites showing (a) M100 and M300, (b) tensile strength, (c) elongation at break, and (d) hardness.....33
4.8	FESEM images and EDS mapping of fractured NR and NR/RSi composites.....34
4.9	Mechanical properties of NR/5RSi and NR/VTES/5RSi composites showing (a) M100 and M300, (b) tensile strength, (c) elongation at break, and (d) hardness.....36

LIST OF FIGURES (Continued)

Figure	Page
4.10	Chemical bonding of NR/VTES/RSi composite.....37
4.11	Cure characteristics of NR and NR/VTES/RSi composites showing (a) ML and MH and (b) t ₂ and t _{c90}38
4.12	Mechanical properties of NR and NR/VTES/RSi composites showing (a) M100 and M300, (b) tensile strength, (c) elongation at break, and (d) hardness..... 40
4.13	FESEM images and EDS mapping of fractured NR and NR/VTES/RSi composites..... 41
4.14	Mechanical properties of NR, XSBR, and their blends showing (a) M100 and M300, (b) tensile strength, (c) elongation at break, and (d) hardness..... 43
4.15	FESEM images of fractured NR, XSBR, and their blends..... 44
4.16	Cure characteristics of 2NR/XSBR and 2NR/XSBR/RSi composites showing (a) ML and MH and (b) t _{s2} and t _{c90}45
4.17	Mechanical properties of 2NR/XSBR and 2NR/XSBR/RSi composites showing (a) M100 and M300, (b) tensile strength, (c) elongation at break, and (d) hardness..... 47
4.18	FESEM images and EDS mapping of fractured 2NR/XSBR and 2NR/XSBR/RSi composites.....48
4.19	Mechanical properties of unadded PMM and PMM showing (a) tensile strength, (b) flexural strength, and (c) compressive strength.....51
4.20	Water absorption at different immersion times of unadded PMM and PMM...53
4.21	FESEM images of fractured surfaces of unadded PMM and PMM.....54
4.22	Mechanical properties of NR, 2NR/XSBR, and 2NR/XSBR/5RSi at the same content in mortar.....54

SYMBOLS AND ABBREVIATIONS

%	=	Percent
MPa	=	Mega Pascal
g	=	Gram
N	=	Normality
pH	=	Potential of hydrogen ion
°C	=	Degree Celsius
nm	=	Nanometer
m ² /g	=	Square meter per gram
M	=	Molarity
rpm	=	Revolutions per minute
wt%	=	Weight percentage
mm	=	Millimeter
cm ⁻¹	=	Reciprocal centimeter
θ	=	Theta
kN	=	Kilonewton
mm/min	=	Millimeter per minute
kN/s	=	Kilonewton per second
N	=	Newton
mm ²	=	Square millimeter
g/cm ²	=	Gram per square centimeter
cm ³ /g	=	Cubic centimeter per gram
dNm	=	Decinewton meter
SiO ₂	=	Silicon dioxide
K ₂ O	=	Potassium oxide
CaO	=	Calcium oxide
TiO ₂	=	Titanium dioxide

SYMBOLS AND ABBREVIATIONS (Continued)

MnO ₂	=	Manganese dioxide
Fe ₂ O ₃	=	Iron(III) oxide
C	=	Carbon
O	=	Oxygen
Mg	=	Magnesium
Al	=	Aluminum
Si	=	Silicon
Ca	=	Calcium