Properties of Mortar Mixing with Medium Ammonia Concentrated Latex

P. khamput and K. Suweero

***Abstract*— *The aim of this research is to use medium ammonia concentrated latex mixed in mortar for developing the strength and thermal insulation properties. The concentrated latex to cement ratios (P/C) are fixed at 0.000, 0.025, 0.050, 0.075, 0.100, 0.125 and 0.150 by weight. Cement to sand ratio is maintained at 1: 2.75. Water to cement ratio is 0.50 (not include water content in concentrated latex). The mortar samples are cast for testing the properties followed the ASTM standard. From the results, it is found that the increase of concentrated latex affects in decreasing of density, elongation, compressive strength, bending strength and coefficient of thermal conductivity. For rate of water absorption, it decreases considerably when the concentrated latex is added at small amount but it becomes higher values when adding the concentrated latex reaches at some amount. In the future, this indicates that the use of concentrated latex at some suitable amount can develop the concrete having the properties of waterproof and thermal insulation.*

***Keywords*— Mortar, Concentrated latex, Medium ammonia, Natural rubber**

1. INTRODUCTION

Para-rubber is the compound containing the large molecules. Chemically, it is categorized into the polymer compound. Its special characteristic is highly flexible which can be called elastomer [1]; the name of elastomer is often used interchangeably with the term rubber, and is preferred when referring to vulcanisates. Thus some text books give the meaning of elastomer to vulcanized product [2]. Normally, the flesh latex from para-rubber trees composes of rubber content from 20% up to 45% (depends on many factors), non-rubber components around 5% and the rest is water. In order to transport the latex to the factories, the latex is concentrated for saving the transportation cost. The preferred level of concentration is 60% and it is so-called concentrated latex. Using of concentrated latex makes the products to have the regular quality when compared to that with flesh latex. This is because the non-rubber components are separated during concentration process. There are four processes for producing the concentrated latex; evaporation, creaming, electro decantation and centrifuging. The method of centrifuging is used widely in economic scale (around 90% of total production of concentrated latex) [3]. The quality of concentrated latex is depended on the quality of flesh latex, thus some properties of flesh latex must be examined and controlled [4].

In Thailand, the procedure of preservation of concentrated latex is performed by using high content of ammonia (HA). For a few factories, the preservation process is done by using ammonia and some types of substances (TA-TZ). However, currently, the system of preservation is lied between HA and LA and it is called MA latex (medium ammonia). At the present day, the purchasing of this type of latex is ordered from requirement of the customers under ISO standard which is defined by total solid content (TSC) and dry rubber content (DRC) [6-7].

Thailand stepped into the first rank in producing and exporting the natural rubbers by producing and exporting at 34% and 47% of overall capacities in the world. The income from exporting the rubbers in 2004 reached 136,704 million baths. In the same year, the natural rubbers were produced at 2.97 million tons and 89% of those were exported in form of raw materials. By previous reason, it is the cause that Thailand must rely on markets at outside of the country. Thus in order to attain the leader in para-rubber of the world and have the high potential in competition in the world market, the reengineering of the products of para-rubber and rubber industries is necessary [8].

Currently, a few researchers in our country study the applications of latex for utilizing in construction materials. The use of para-rubber instead of asphalt in construction the streets was performed by Ref [9]. Subsequently, the preliminary study of applying latex in concrete was examined [10-11], paracrete blocks [12], the use of latex for improving the strength and reducing the water absorption of adobe blocks [13], curing concrete by using latex [14], soil-cement blocks mixing with latex [15], furnishing materials by using coir fiber and latex [16], para-rubber plates for capping the concrete specimens [17], concrete blocks mixing with flesh latex [18] and moderate lightweight concrete mixing with flesh latex [19]. By continuing this line of research, the author and MTEC will study the properties of mortars mixing with the vulcanized latex [20]. Some parts of this work will present in this paper which aims to study the preliminary results of mortars mixing with medium ammonia latex for acquiring the information in further development of using latex in concrete.

P. Khamput. Author is with Department of Civil Engineering, Rajamangala University of Technology Thanyaburi, Klong 6, Thanyaburi, Pathumthani 12110, Thailand, E-mail: choomy_gtc@hotmail.com

K Suweero. Author is with Technology Licensing Office (TLO) Rajamangala University of Technology Thanyaburi, Klong 6, Thanyaburi, Pathumthani 12110, Thailand, E-mail: siam_macho@hotmail.com

2. MATERIALS AND METHODS

Mix design of mortars

The mix design of mortars can be calculated by two approaches.

1) Weight ratios
   - cement-sand ratio equals to 1:2.75
   - water-cement ratio is 0.5 (not include the water content in concentrated latex)
   - latex-cement ratios are 0.000, 0.025, 0.050, 0.075, 0.100 and 0.150 by weight
2) Design rubber formulas compared from rubber content at 100 parts (phr).

The design ratios from two approaches are summarized in Tables 1-3 below.

Table 1. Solid and liquid ratios of latex

P/C	0.000	0.025	0.050	0.075	0.100	0.125	0.150
Latex	0.000	0.025	0.050	0.075	0.100	0.125	0.150
Solid	0.000	0.015	0.030	0.045	0.060	0.075	0.090
Liquid	0.000	0.010	0.020	0.030	0.040	0.050	0.060

Table 2. Design formulas in phr unit

P/C	0.000	0.025	0.050	0.075	0.100	0.125	0.150
Rubber	0	100	100	100	100	100	100
Cement	1	6667	3333	2222	1667	1333	1111
Sand	2.75	18333	9167	6111	4583	3667	3056
Water+ Liquid	0.5	3400	1733	1178	900	733	622

Table 3. Water content at various ratios of latex

P/C	0.000	0.025	0.050	0.075	0.100	0.125	0.150
W/C	0.50	0.50	0.50	0.50	0.50	0.50	0.50
(W+L)/C	0.50	0.51	0.52	0.53	0.54	0.55	0.56

Materials

1) Portland cement type I under industrial standard 15 [21].
2) Sand under industrial standard 566-2528 [22].
3) Tab water.
4) Medium ammonia latex under ISO 2004-1997 and industrial standard 980- 2533 [23] mixing with non-ionic surfactants at 4% of concentrated latex. The properties of medium ammonia latex are shown in Table 4.

Table 4. Properties of concentrated latex

Properties	ISO limits	Test results
Total solid content ;T.S.C. (% by weight)	61.50 min	61.58
Dry rubber content D.R.C. (% by weight)	60.00 min	60.19
Non-rubber solid %	2.00 max	1.39
Ammonia content (on total weight)	0.59 max	0.47
Ammonia content (on water phase)		1.197
PH Value (at 25 C)		10.30
KOH Number	1.00 max	0.51
Volatile fatty acid number (VFA)	0.20 max	0.036
Mechanical stability time @55% TS., Sec.	650 min	670
Magnesium content (on solid), ppm		30
Odour of latex		Sweet
Colour of latex		White
Colour of film		-

Remark: tested by Mingung Latex Industry Co.Ltd.

Testing procedure

The mortars are cast under the proportions that were calculated previously. The testing procedures are listed below.

1) Casting the mortar of the dimension 5 cm × 5 cm × 5 cm for finding the water absorption, density and compressive strength under ASTM C109 [24].
2) Casting the mortar of the dimension 4 cm × 4 cm × 16 cm for testing the bending strength under ASTM C384 [25].
3) Casting the mortar of the dimension 2.5 cm × 2.5 cm × 28.5 cm for evaluating the elongation under ASTM C596 [26].

3. RESULTS AND DISCUSSION

Figures 1-7 show the testing results about water absorption, density, elongation, compressive strength, bending strength coefficient of thermal conductivity and high resolution pictures of mortars.

Water absorption

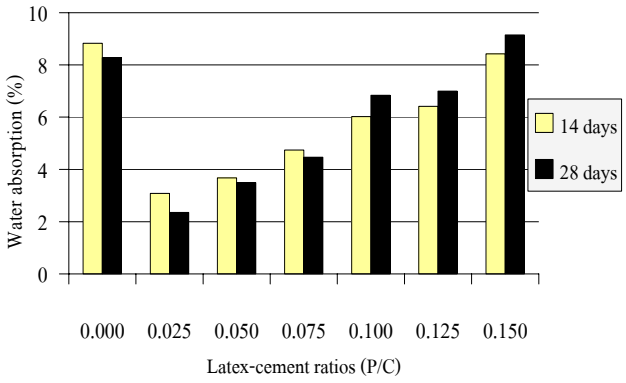


Figure 1. The relationship between water absorption and latex-cement ratios

Density

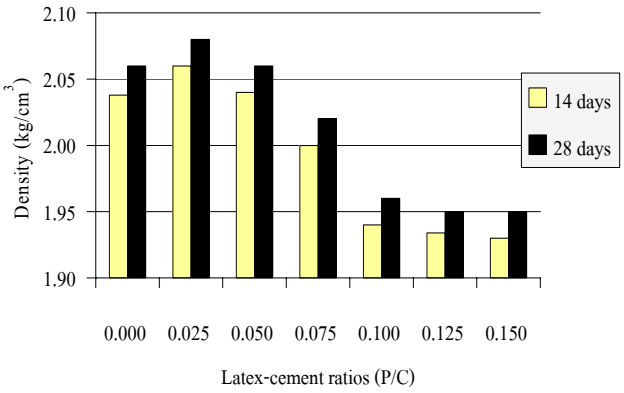


Figure 2. The relationship between density and latex-cement ratios

Elongation

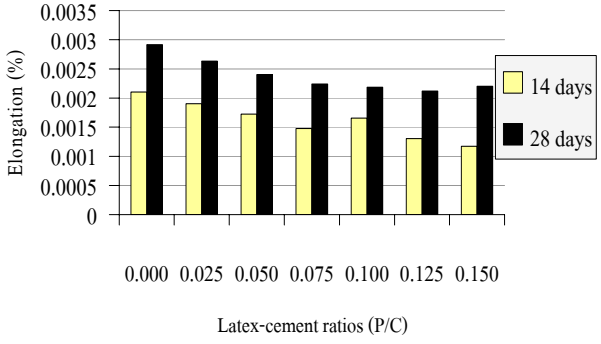


Figure 3. The relationship between elongation and latex-cement ratios

Compressive strength

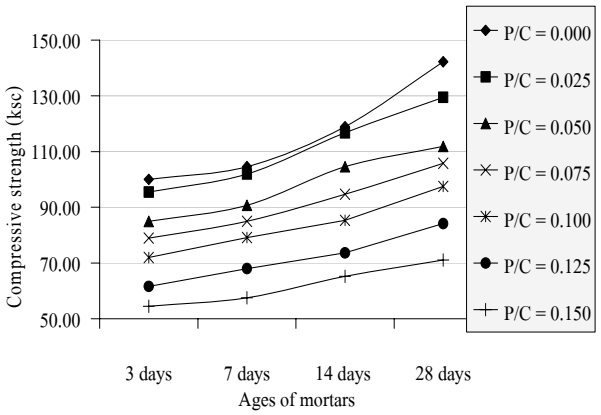


Figure 4. The relationship between compressive strength and ages of mortars

Bending strength

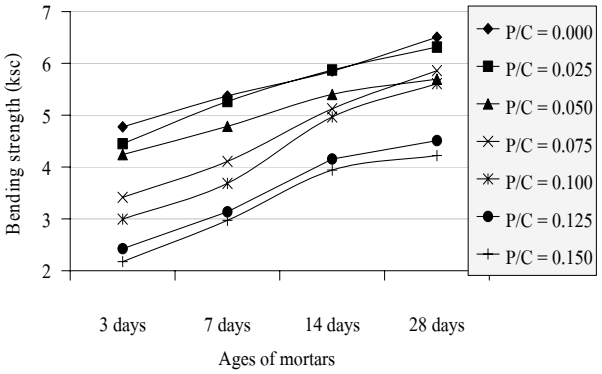


Figure 5. The relationship between bending strength and ages of mortars

Coefficient of thermal conductivity

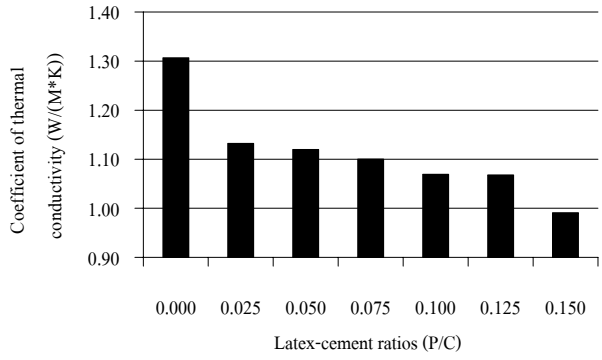
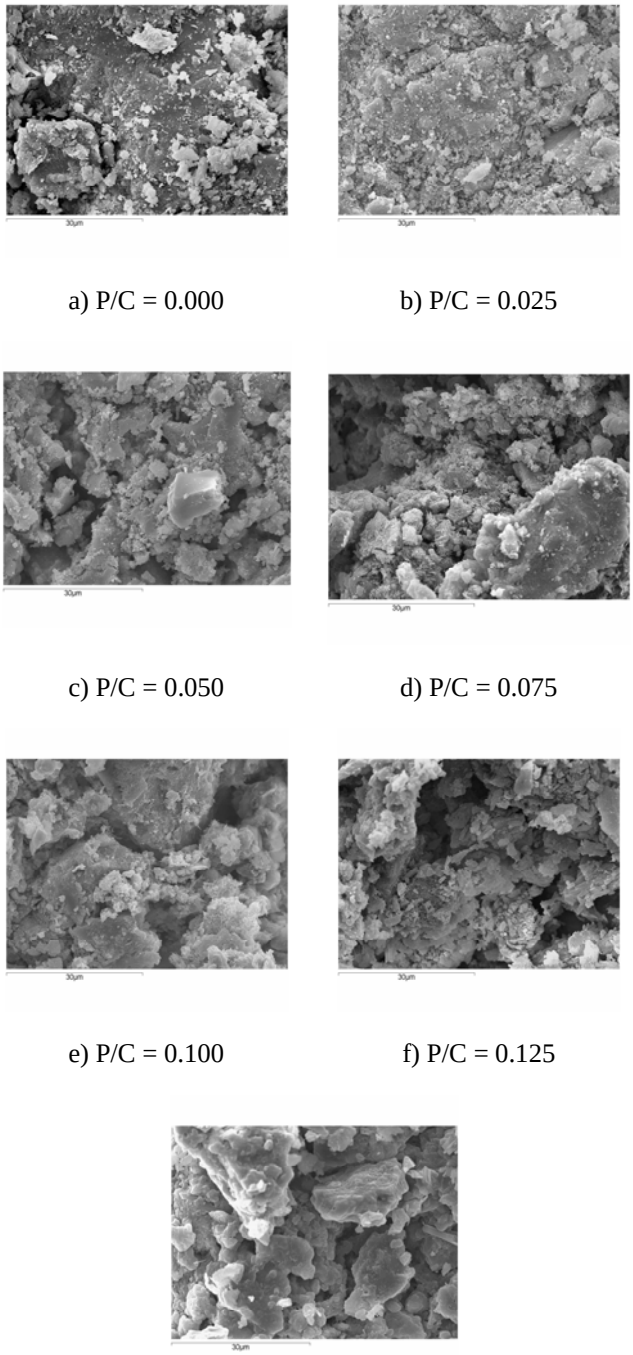


Figure 6. The relationship between coefficient of thermal conductivity and latex-cement ratios

Images from SEM: magnification X 2,000



a) P/C = 0.000 b) P/C = 0.025

c) P/C = 0.050 d) P/C = 0.075

e) P/C = 0.100 f) P/C = 0.125

g) P/C = 0.150

Figure 7. Magnification pictures of mortars at various latex-cement ratios

The setting of natural rubber can be explained that latex is a stable dispersion of the rubber particles in aqueous medium which is called serum. Moreover latex also has the other non-rubber matters such as lutoid [28] and protein which is absorbed partially around the rubber particles. The absorbed protein will form a layer for protecting the gathering of rubber particles. This causes the stable dispersion of the latex. In addition, the negative charges of carboxylate ($RCOO^-$) in protein induce the pushing force between the particles. The loss of stability in form of latex can be occurred when the latex is dehydrated in protein level or the negative charges of carboxylate are eliminated. This situation leads to self-assembly into form of coagulum and separates from serum [29].

From figure 1, it is found that the water absorption of mortars at P/C = 0.025 is reduced considerably since compression and the change of temperature due to hydration reaction in mortars make the rubber particles gathering with long-range order (crystallization) [3] or, as previous mention, the setting of latex due to loss its stability forms the film layer infiltrating into the mortars [30]. The film layer covering the aggregates and reducing the voids (see figure 7b) in mortar results in increasing the density and waterproof properties which cause the reduction of water absorption. However, the rising of P/C over 0.025 leads to increase of water absorption (see figures. 7c-7g). This can be explained that the increase of latex leads to self-grouping of rubber particles and then the number and size of voids in mortar are increased which makes the increase of water absorption. Moreover, the increase of voids in mortar results in decreasing of density of mortar (see figure 2).

In figure 3, it reveals that the elongation is decreased as latex is increased since the long-range order of rubber molecules is increased. This means that adding latex into mortar improves the bond in mortar. In comparison with the ages of mortar, the elongation at 28 days is greater than that at 14 days around 0.0005-0.001 %.

In figures 4 and 5, the compressive and bending strengths of mortar increases as ages of mortar increases. However both strengths decreases as latex increases since the increase of latex affects the thicker layer of film covering the aggregates and results in softening surface around the aggregates which is the cause of reducing of the strengths. Another reason is the increase of latex into the mortar means the water-cement ratio is also increased which normally makes the lower strengths in mortar [31].

4. CONCLUSIONS

From the study of properties of mortars mixing with medium ammonia in which 4% (by weight of latex) of non-ionic surfactant is added. The latex-cement ratios for this testing are 0.000, 0.025, 0.050, 0.075, 0.100, 0.125 and 0.150 (by weight). The cement-sand ratio is kept at 1: 2.75 and water-cement ratio is maintained at 0.50. The increase of latex-cement ratio affects the water-cement ratios increasing to 0.50, 0.51, 0.52, 0.53, 0.54, 0.55 and 0.56 respectively. From the results, it is found that the density, elongation, compressive strength, bending strength and coefficient of thermal conductivity tend to drop as latex increases. The water absorption decreases considerably for small amount of latex but it turns to increase when the latex is added over some certain value. This indicates that the suitable amount of latex can make waterproof and thermal insulation concrete. From this study, the most suitable amount of latex for producing the waterproof concrete is P/C = 0.025 which gives water absorption at 2.5 %. For the best thermal insulation property, the latex-cement ratio should be 0.150 which obtains the lowest coefficient of thermal conductivity (0.99 W/(M*K)).

5. SUGGESTIONS

The value of coefficient of thermal conductivity in this testing is higher than those from expectation since the size of this testing (at MTEC: 5x5x1 cm^3) is much smaller than those presented in previous papers (at department of science service: 30x30x2.5 cm^3) [33-34]. The smaller size of specimens may be obtained the effect from irregular setting of concentrated latex in mortars but the larger size of the samples is affected insignificantly. Thus for further study, the specimens should be tested from both MTEC and department of science service.

In this research, the water-cement ratio is not constant due to water content containing in latex. Thus for further study, the design formula should be calculated by mean of comparing with 100 parts of rubber content (phr) for keeping water-cement ratio as a constant.

Finally, the latex-cement ratios within the range of 0.000-0.025 should be studied since there is high uncertainty in this region.

ACKNOWLEDGMENT

This paper was supported by National Metal and Materials Technology Center (member of NSTDA) under the project “A study of properties of mortar mixing with latex from para-rubber” (Grant number: MT-B-50-POL-47-399-G).

REFERENCES

[1] Craig, A.S. 1969. Dictionary of Rubber Technology, London Newnes-Butter Worths, p. 59

[2] Blow, C.M. and Hepburn, C. 1982. Rubber Technology and Manufacture, second edition, Butterworth Scientific, p. 31.

[3] Kajornchaiyakul, V. 2006. Natural Rubber: Manufacturing and Applications, first edition, Bangkok.

[4] Muniandy, E.V. 1998. Concentrate Production, Factory Operation and Maintenance in Latex Concentrate & Prevulcanised latex, Malaysian Rubber Board, Malaysia, pp. 1-2.

[5] Kajornchaiyakul, V. 2001. Lecture note on Process and Cleaner Technology in The Rubber Industry, Rubber Research Institute of Thailand, pp. 44-45.

[6] Kajornchaiyakul, V. 2001. Testing Procedure for Concentrated Latex, Technical Report no. 2/2544, Rubber Research Institute of Thailand, pp. 1-4.

[7] Kajornchaiyakul, V. 2001. Lecture note on Process and Cleaner Technology in The Rubber Industry, Rubber Research Institute of Thailand, pp. 46-47.

[8] Reengineering the Rubber and Products of Rubber 2006-2008, Rubber Research Institute of Thailand. http://www.rubberthai.com.

[9] The Use of Para-rubber Mixing With Asphalt, http://www.yanpara.com.

[10] Siriphan, S., Boonnum, P., Roha, K. and Kumnerdvar, A. 2005. The Use of Natural Rubber for Developing Concrete Work, NCCE 10, Chonburi, MAT 205- MAT 210.

[11] Kovuttikulrangsie, S. and Worlee, A. 2006. A Preliminary Study for Applying the Natural Latex into Construction, Para-rubber Research for Sustainable Future, pp. 131-136.

[12] Suwannaprecha, V. Lightweight Bricks: Paracrete. http://www.thailandrubber.thaigov.net/ news_a16.pdf.

[13] Laokomain, V. 2004. Improving the Efficiency of Water Protection of Adobe Houses, Master Thesis, Thammasart University.

[14] Kamsuwan, S. 2006. A Study of Curing Concrete with Latex, 2nd Annual Concrete Conference, Udonthani, MAT1- MAT 5.

[15] Ruthankun, N. 2007. Soil-cement Blocks Mixing with Latex, NCCE 10, Phitsanulok.

[16] Khamput, P. and Suvero, K. 2007. A Study of Forming the Finishing Plates from Coir Fiber and Natural Rubber, The Third Conference of Research Narasuan, Narasuan University, Phisanulok.

[17] Khamput, P. 2007. A Study of Properties of Para-rubber Plates for Using as the Capping on Concrete Specimens for Compression Test Instead of Molten Sulphur, The first Thailand-Japan Rubber Symposium, Chonburi.

[18] Khamput, P. 2007. A Study of Using the Natural Latex as the Admixture in Concrete Blocks, Research and Development Journal of the Engineering Institute of Thailand, 18: 21-25.

[19] Khamput, P. 2007. Using the Latex for Improving the Properties of Compressive Strength and Thermal Insulation of Lightweight Autoclave Aerated Concrete Blocks, Research and Development Journal of KMUTT, 30: 363-376.

[20] Chuayjuljit, S. 2005. Rubber Technology, Department of Material Science, Faculty of Science, Chulalongkorn University, Bangkok.

[21] Thai Industrial Standard Institute, 1979. Standard of Cement Portland Industry, Vol. 1, TIS. 15 Vol.1-2532, Ministry of Industry, Bangkok.

[22] Thai Industrial Standard Institute, 2004. Standard of Aggregates, TIS. 566-2528, Ministry of Industry, Bangkok.

[23] Thai Industrial Standard Institute, 1980. Standard of Natural Concentrated Latex, TIS. 980-2533, Ministry of Industry, Bangkok.

[24] American Society for Testing and Materials, 2001, ASTM C109/C109M-99, Standard test Method for Compressive Strength of Hydraulic Cement Mortars [Using 2-in or [50mm] cube specimens], Annual Book of ASTM Standards. Vol. 04.01., Philadelphia.

[25] American Society for Testing and Materials, 2001, ASTM C348-97, Standard test Method for Flexural Strength of Hydraulic Cement Mortars. Annual Book of ASTM Standards, Vol. 04.01., Philadelphia.

[26] American Society for Testing and Materials, 2001, ASTM C596-07, Standard test Method for Drying Shrinkage of Mortar Containing Hydraulic Cement. Annual Book of ASTM Standards, Vol. 04.01., Philadelphia.

[27] American Society for Testing and Materials, 2001, ASTM C177-04, Standard test Method for Steady-state Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-hot-plate Apparatus, Annual Book of ASTM Standards, Vol. 04.06., Philadelphia.

[28] Blackley, D.C. 1997. Polymer Latices Science and Technology, Vol. 2 Types of Latices, Second Edition, Chapman & Hall, pp.78-79.

[29] Lecture Note for Diploma of Natural Rubber Processing, 1979. Rubber Research Institute of

Malaysia, Kuala Lumpur.
[30] Ohama, Y. 1987. Principle of Latex Modification and Some Typical Properties of Latex-modified Mortars and Concretes, ACI Material Journal, Title no. 84-M45: 511-518.
[31] Jindaprasert, P. and Jaturapitakkul, C. 2006. Cement Pozzolan and Concrete, Special Edition, Thai Concrete Association, Bangkok, p. 117.
[32] Chindawanik, T. 1997. Series of Media Book: Architecture and Technology, First Edition, Chulalongkorn University Press, Bangkok.
[33] Khamput, P. 2006. Using Latex from Para-Rubber for Developing Strength and Thermal Insulation Properties of Concrete Blocks, Asian Symposium on Materials and Processing 2006, Bangkok.
[34] Khamput, P. 2006. A Study of Using Natural Rubber Mixed in Moderate Lightweight Concrete, Asian Workshop on Polymer Processing 2006, Bangkok.