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Properties of Mortar Mixing with Low Ammonia Concentrated Latex

P. Khamput^{a,*}, K. Suweero^b

^aFaculty of Engineering, Rajamangala University of Technology Thanyaburi, Pathumthani 12110, Thailand

^bTechnology Licensing Office of Rajamangala University of Technology, Pathumthani 12110, Thailand

Abstract

The aim of this research is to use low 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 including water content in concentrated latex). The mortar samples cast for testing the properties followed the ASTM standard. From the results, it is found that the increase of concentrated latex resulted 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 the values becomes higher when adding the concentrated latex at the same amount. In the future, this indicates that the use of concentrated latex at some suitable amount can develop the concrete with the properties of waterproof and thermal insulation.

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Keywords: Mortar; concentrated latex; low 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

* Corresponding author. *E-mail address:* choomy_gtc@hotmail.com

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, one of famous system of preservation is called LA latex (low 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 low ammonia latex for acquiring the information in further development of using latex in concrete.

2. Methodology

2.1 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	6,667	3,333	2,222	1,667	1,333	1,111
Sand	2.75	18,333	9,167	6,111	4,583	3,667	3,056
Water+Liquid	0.5	3,400	1,733	1,178	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

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)	0.29 max	0.24
Ammonia content (on water phase)		0.611
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.

2.2 Materials

- 1) Portland cement type I under industrial standard 15 [21]
- 2) Sand under industrial standard 566-2528 [22]
- 3) Tap water
- 4) Low 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 low ammonia latex are shown in Table 4.

2.3 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 5x5x5 cm³ for finding the water absorption, density and compressive strength under ASTM C109 [24].

- 2) Casting the mortar of the dimension $4 \times 4 \times 16 \text{ cm}^3$ for testing the bending strength under ASTM C384 [25].
- 3) Casting the mortar of the dimension $2.5 \times 2.5 \times 28.5 \text{ cm}^3$ for evaluating the elongation under ASTM C596 [26].
- 4) Casting the mortar of the dimension $5 \times 5 \times 1 \text{ cm}^3$ for determining the coefficient of thermal conductivity under ASTM C177 (tested by MTEC).

3. Results and discussion

Fig. 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.

3.1 Water absorption

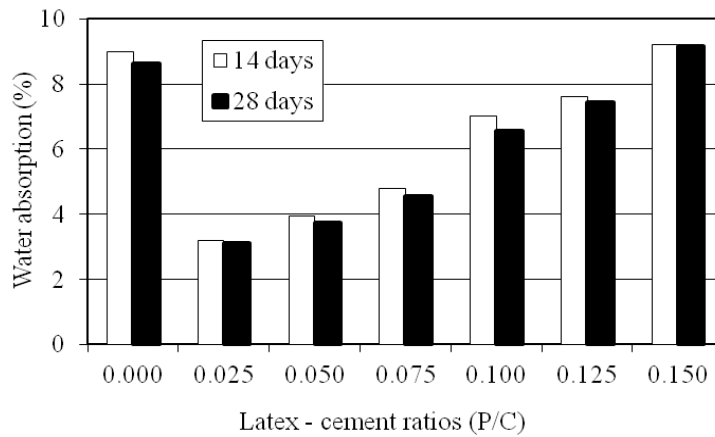


Fig. 1. The relationship between water absorption and latex-cement ratios

3.2 Density

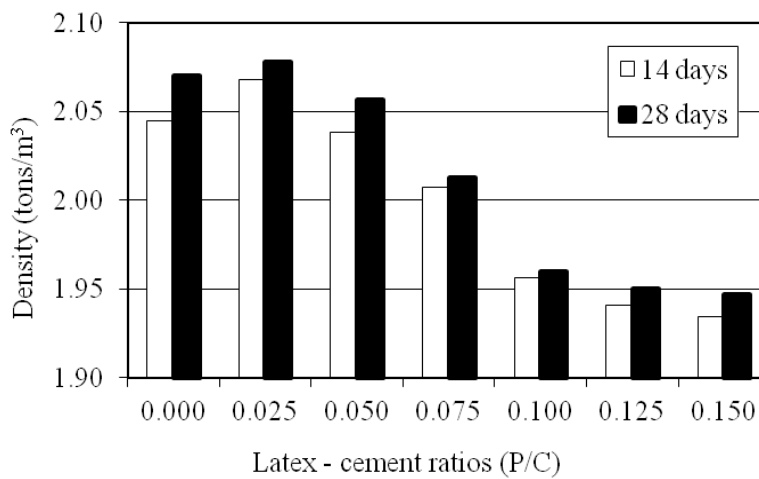


Fig. 2. The relationship between density and latex-cement ratios

3.3 Elongation

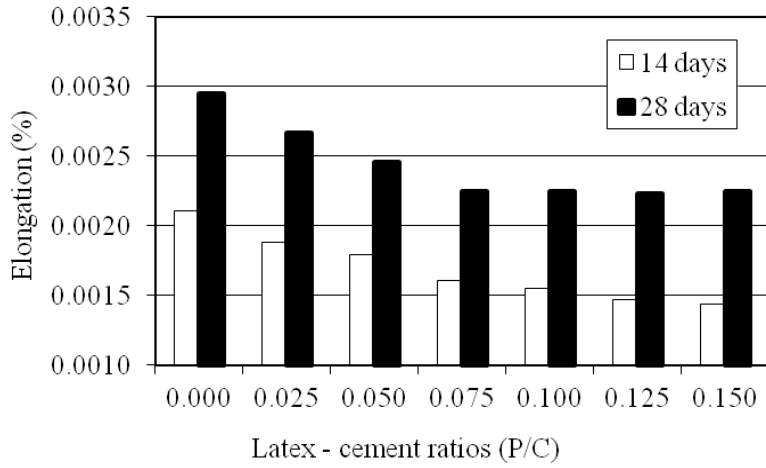


Fig. 3. The relationship between elongation and latex-cement ratios

3.4 Compressive strength

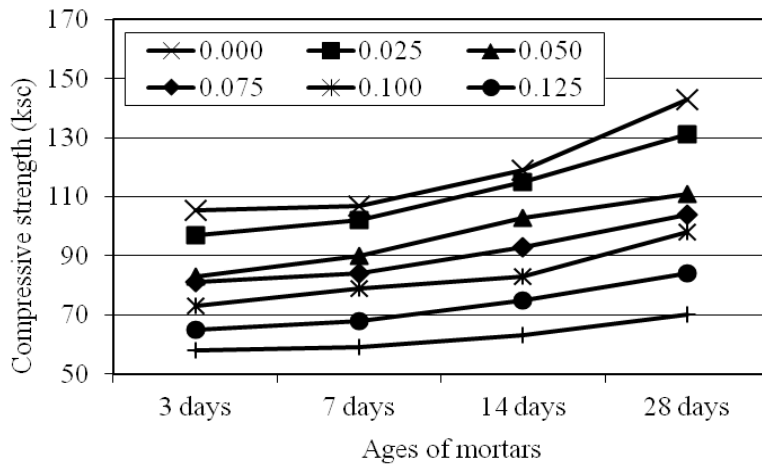


Fig. 4. The relationship between compressive strength and ages of mortars

3.5 Bending strength

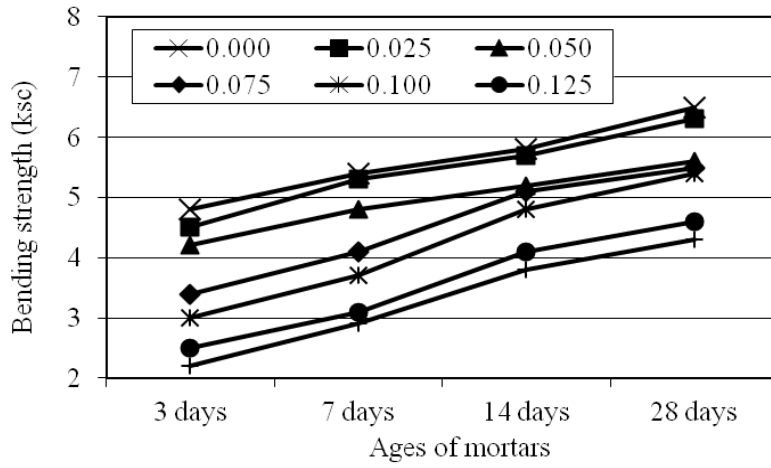


Fig. 5. The relationship between bending strength and ages of mortars

3.6 Coefficient of thermal conductivity

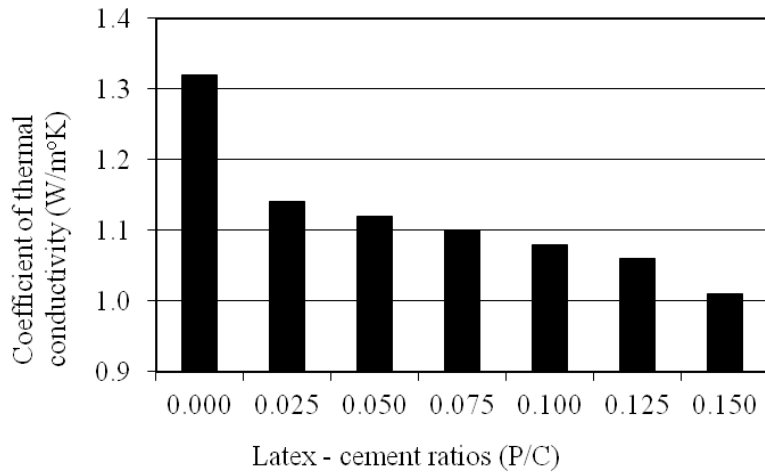


Fig. 6. The relationship between coefficient of thermal conductivity and latex-cement ratios

3.7 Images from SEM: magnification X 2,000

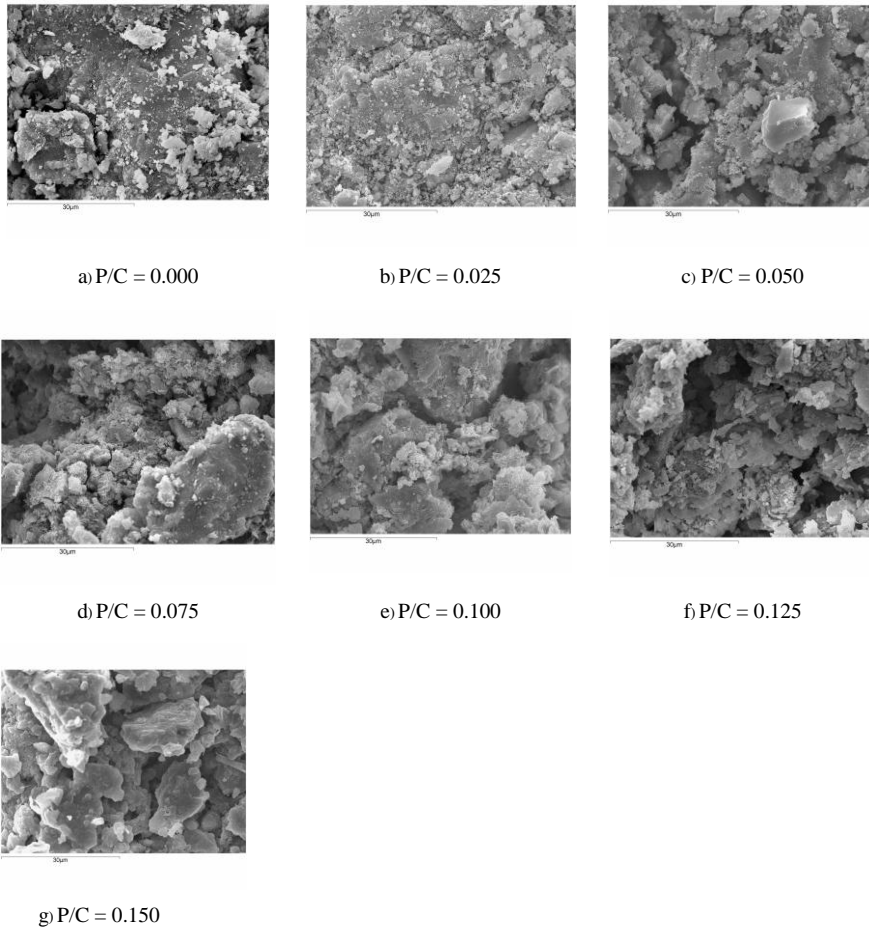


Fig. 7. Magnification pictures of mortars at various latex-cement ratios

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 Fig. 1, it is found that the water absorption of mortars at $\text{P/C} = 0.025$ 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 Fig. 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 Fig. 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 Fig. 2).

In Fig. 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 Fig. 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].

In Fig. 6, the coefficient of thermal conductivity decreases dramatically as latex increases. This is because the rising of the number of voids in mortar (see Fig. 7) which means the density of mortar is decreased (see Fig. 2) and thus the low density material yields the low value of coefficient of thermal conductivity [32]. In the other word, the lower density gives the better thermal insulation property.

4. Conclusions

From the study of properties of mortars mixing with low 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/(m²K)).

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 cm³) is much smaller than those presented in previous papers (at department of science service: 30x30x2.5 cm³) [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.

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