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AN INVESTIGATION AND TEST OF NATURAL RUBBER LATEX SOIL CEMENT ROAD

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ABSTRACT

This research applies natural rubber latex (NRL) to improve the quality of cement clay roads. In laboratory test, multiple specimens have been prepared. The research uses high ammonia latex concentrate (60% Dry Rubber Content (DRC)), mixed with surfactant and pure water. Then it was sprayed and mixed to the red dirt road that has been admixed with cement. The red dirt material used for the research was taken from Ubon Ratchathani province, northeastern of Thailand. The dirt soil is a mix of gravel, sand, and clay with poorly graded grain size distribution. The test uses varying amount of cement (4%, 6% and 8%), and NRL (0%, 5%, 8%, 10%). From the experiment, the best mixture ratio is to use NRL 5%, cement 8%, and surfactant 2%. With seven-day air-curing, the averaged compressive strength of the rubber latex soil cement specimens was 1.72 MPa.

1. Introduction

Thailand, the world major exporters of rubber latex, is likely to produce rubber latex even more. The global natural rubber latex (NRL) prices had once been surged. Over supplies, plunging NRL prices (one-fifth of their peak) have driven more than six million natural-rubber Thai growers into a corner (Kotani, 2016). The Royal Thai Government has issued a national policy regarding this matter to increase the uses of NRL. One of rescue programs is to use NRL in the road constructions, such as asphaltic concrete roads. However, the use of NRL required complicated process with typical mixture machinery. It is learned that asphaltic concrete roads have longer product life with lesser maintenance. Nevertheless, the amount use of NRL is rather limited. Thus this research attempts to apply NRL to the red dirt roads, as they are many thousands of such roads in Thailand. These red dirt roads are used for transporting agricultural

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products to markets. After using for a short period, these become rough and corrugated red dirt roads, probable with soil settlements and cracks. Frequent yearly maintenances are needed to maintain the roads in usable and comfortable conditions, needing huge amount of budgets. To these dilemmas, this work studies and applies NRL as an additive to soil cement road, to better serves the road users.

2. Literature Review

Many decades ago, Fernando and Nadarajah (1969) applied natural rubber latex in road construction in Malaysia. Nrachai et al. (2005) and Nopparat et al. (2012) studied on the modification of asphalt cement by NRL for pavement construction.

Shafie et al. (2013) reported the effect of blending interaction on physical properties of natural rubber latex (NRL) modified asphalt binder. Later, Shaffie et al. (2015) applied natural rubber latex polymer modified binder (NRMB) to study stripping performance and volumetric properties evaluation of hot mix asphalt (HMA) mix design.

Chowdhury et al (2017) reported the effect of natural rubber and zycotherm on moisture performance of asphalt mixtures. It found that natural rubber and warm additives can mitigate moisture damage of dense-graded asphalt mixtures. An overview on natural rubber application for asphalt modification has been summarized and reported (Azahar et al., 2016).

Lukjan et al. (2017) investigated the use of recycled low density polyethylene (LDPE) plastic and NRL as polymer additives in asphaltic concrete pavement. The result showed that adding 2.5% LDPE and 2.5% NRL by mass of optimum binder content (4.90%) can enhance both the volumetric and mechanical properties of the mixture with better durability, rutting resistance, and stiffness than conventional asphalt concrete.

All the works have been done and reported so far from researchers involve with adding NRL to enhance asphaltic pavements. No work has been on using NRL to soil cement road which this work is about.

3. Study Method

3.1 Preparation of Materials

Red dirt soil in this study is obtained from Amphoe Trakan Phuet Phon (15°36′44″N 105°1′19″E), Ubon Ratchathani Province, Thailand. The main reason is the abundance of red dirt soil in the area. Portland cement type 1 is employed in this study, which is used for general constructions. Natural rubber latex (NRL) liquid should have high ammonia latex concentration (60% Dry Rubber Content (DRC)). Surfactant is available from the market. A gallon of clean water is prepared. Figure 1 exhibits all materials used in this study.

Figure 1: Materials used in this study.

3.2 Testing

3.2.1 Testing of Red Dirt Soil

To learn characteristics of material, Trakan Phuet Phon red dirt soil is tested for Liquid Limit, Plastic Limit (ASTM D4318), Sieve Analysis, Coarse Aggregates (ASTM C136/C136M), Modified Compaction Test (ASTM D1557), and Unconfined Compressive Strength (ASTM D2166 / 2166M).

3.2.2 Trial Mix Cement and NRL

The test varies amount of Portland cement and NRL. This study has 12 trial batch demonstrations, with 2% surfactant. Detail of trial batch demonstrations is given in Table 1: Compressive strength of molded soil-cement cylinders is determined according to ASTM D1633.

Table 1: Detail of trial batch demonstrations of trial mix cement and NRL.

Trial Batch #	% cement	% NRL liquid	surfactant
1	4	0	2%
2		5	
3		8	
4		10	
5	6	0	
6		5	
7		8	
8		10	
9	8	0	
10		5	
11		8	
12		10	

Each trial batch demonstration uses red dirt soil 2500grams. Red dirt soil is dry mixed with cement, according to Table 1. Then water and surfactant is added to the mix, followed by NRL, as demonstrated in Figure 2.

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Figure 2: A trial batch demonstration showing a mix together of soil, cement, water, surfactant and NRL liquid.

For modified compaction test (ASTM D1557), the mixture from each trial batch demonstration is placed into a mold, total five layers (about 500grams each). Each layer is compacted following ASTM D1557, to finally get a specimen. The process repeated to get total three specimens for each trial batch class. All trial batch demonstration specimens are placed in plastic bags in order to prevent moisture change, see Figure 3. After seven-day curing, specimens are soaked in water for two hours, and then dried in room temperature. Unconfined compression test (ASTM D2166 / 2166M) is then executed, see Figure 4.

Figure 3: trial batch demonstration specimens and curing

Figure 4: Unconfined compression test.

3.2.3 Friction Test

To find anti-slip of natural rubber latex soil cement, the friction test is executed according to AASHTO T279-96. The Portable Skid Resistance Tester (British Pendulum Tester (BPT)) is used, *see* Figure 5.

Figure 5: Portable Skid Resistance Tester (British Pendulum Tester (BPT) of a trial batch demonstration specimen from the mix of natural rubber latex soil cement

4. Test Results

From laboratory experiment of the three samples of red dirt soil supplied from Ubon Ratchathani Province of Thailand, Table 2 gives test result detail in terms of geotechnical engineering properties.

Table 2: Test result of red dirt soil samples.

Properties	Sample#1	Sample#2	Sample#3	Average
Liquid Limit, LL (%)	25.1	24.7	24.8	24.9
Plastic Limit, PL (%)	14.8	14.9	14.8	14.8
Plasticity Index, PI (%)	10.3	9.8	10.1	10.1
% Finer 2"	100.0	100.0	100.0	100.0
% Finer 1"	100.0	95.4	99.5	98.3
% Finer 3/8"	80.2	70.4	76.4	75.7
% Finer No. 4	54.9	45.7	49.2	49.9
% Finer No. 10	42.4	34.6	36.4	37.8
% Finer No. 40	37.5	30.7	32.8	33.6
% Finer No. 200	20.5	16.6	18.3	18.5
Percentage of Wear (%)	32.8	35	34.4	34.1
Maximum Dry Density (t/m3)	2.1	2.1	2.2	2.1
Optimum Water Content (%)	12.1	11.7	9.5	11.1

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When consider values of test result in Table 2, the source material red dirt soil supplied from Ubon Ratchathani Province of Thailand is poorly graded grain size distribution. Los Angeles abrasion test, percentage of wear is rather medium. In overall, the test result is acceptable.

After seven-day air-curing, specimens from all trial batches are tested for compressive strength (q_u) according to standard for unconfined compression test ASTM D2166 / 2166M. Having three specimens of each trial batch, Table 3 shows the average compressive test results.

Table 3: Compressive strength (q_u) of molded soil-cement cylinders mixed with NRL

Trial Batch #	Surfactant	% cement	NRL (%)	Max. dry density (t/m^3)	Avg. q_u (age 7 days) (MPa)
1	2%	4	0	2.22	1.50
2			5	2.21	0.85
3			8	2.26	1.54
4			10	2.28	1.64
5		6	0	2.21	1.38
6			5	2.23	1.14
7			8	2.23	1.33
8			10	2.24	1.50
9		8	0	2.28	1.82
10*			5	2.24	2.11
11			8	2.22	2.04
12			10	2.22	2.16

Note: Trial batch #10 is considered the worthiest mix.

For friction test (AASHTO T279-96) using the Portable Skid Resistance Tester (British Pendulum Tester (BPT) of three specimens with mixture according to Trial Batch#10, it finds that British pendulum numbers (BPN) are 70-77. These numbers are high, thus giving excellent anti-slip to the road users.

5. Discussion

Table 3 shows averaged compressive strengths (q_u) of molded soil-cement cylinders mixed with NRL at different amounts. It can be observed that adding NRL does not necessary increase strength of specimens. This is particular true for 4% and 6% of cement added to the mix. However, when 8% cement is used, soil cement specimen strength seems to better develop. As obviously seen in Table 3, the Trial batches #10, #11 and #12 draw the attention due to rising strengths when adding NRL to the mix. Trial batch #10, using 5% NRL, is considered the worthiest, as compressive strengths are developed closing to Trial batch #12 which use 10% NRL.

During the mix of materials used in this, it should be aware that NRL when mixing with water will be clumped and become more harden. When mixing surfactant with water and adding NRL liquid, it should be used up in two hours before it clumping together.

It should be aware that dirt material obtained from different region will have different soil engineering properties. Before using, a laboratory testing should be performed.

6. Conclusion

This study utilizes NRL liquid to improve strengths of red dirt soil cement roads. The red dirt material is originated from Ubon Ratchathani province, northeastern of Thailand. Even the dirt soil, a mix of gravel, sand, and clay, has poorly graded grain size distribution, test result is acceptable. The NRL has high ammonia latex concentrate (60% Dry Rubber Content (DRC)), mixed with surfactant and pure water. Then it was sprayed and mixed to the red dirt soil that has been admixed with cement. From the compressive strength experiment, the worthiest mixture ratio is to use NRL 5%, cement 8%, surfactant 2%.

7. References

ASTM C136 / C136M. Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates. (*ASTM Volume 04.02 Concrete and Aggregates*).

ASTM D1557. Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort. (*ASTM Volume 04.08 Soil and Rock (I)*: D421 – D5876)

ASTM D1633. Standard Test Methods for Compressive Strength of Molded Soil-Cement Cylinders. (*ASTM Volume 04.08 Soil and Rock (I)*: D421 – D5876)

ASTM D2166 / D2166M. Standard Test Method for Unconfined Compressive Strength of Cohesive Soil (*ASTM Volume 04.08 Soil and Rock (I)*: D421 – D5876).

ASTM D4318 - 17e1. Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils. (*ASTM Volume 04.08 Soil and Rock (I)*: D421 – D5876).

Azahar, N.F.B.M., Hassan, N.B.A., Jaya, R.P., Kadir, M.A.B.A., Yunus, N.Z.B.M. and Mahmud, M.Z.H., 2016. An overview on natural rubber application for asphalt modification. *Int J Agric For Plant*, 2, p.212.

Fernando, M.J. and Nadarajah, M. 1969. Use of natural rubber latex in road construction. *Rubber Res Inst Malaya Journal*.

Kotani, Hiroshi. 2016. Plunging prices drive world's biggest producer out of business. *Nikkei Asian Review*. http://asia.nikkei.com/Business/Plunging-prices-drive-world-s-biggest-producer-out-of-business

Nopparat, V., Jaratsri, P., Nuchanat, N. 2012. Modification of asphalt cement by natural rubber for pavement construction, *Rubber Thai J*. 1, 32–39.

Nrachai, T., Chayatan, P., and Direk, L. 2005. The modification of asphalt with natural rubber latex. *Proc. Eastern Asia Soc. Transp. Stud*. **5**, 679–694.

Shafie, E., Ahmad, HJ., Arshad, K., Kamarun, D., and Shafie, A. 2013. Effect of blending interaction on physical properties of natural rubber latex (NRL) modified asphalt binder, National Postgraduate Seminar, Universiti Teknologi MARA, Shah Alam, Malaysia.

Shaffie, E., Ahmad, J., Arshad, A.K., Kamarun, D. and Kamaruddin, F., 2015. Stripping performance and volumetric properties evaluation of hot mix asphalt (HMA) mix design using natural rubber latex polymer modified binder (NRMB). In InCIEC 2014 (pp. 873-884). Springer, Singapore.

Chowdhury, P.S., Kumar, S. and Sarkar, D., 2017. Effect of Natural Rubber and Zycotherm on

*Corresponding authors (W.Raksuntorn and B.Witchayangkoon). Tel: +66-2-564-3005 E-mail: drboonsap@gmail.com.

Moisture Performance of Asphalt Mixtures. 71st *RILEM Annual Week & ICACMS 2017*, Chennai, India, 3– 8 September.

Lukjan, A., Phoonnual, A., Laksanakit, C. and Jaritngam, S., 2017. Utilization of Recycled Plastic and Natural Rubber in Asphalt Concrete to Improve Performance of Flexible Pavement. *Suranaree Journal of Science & Technology*, 24(4).

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