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# Effect of Para rubber latexand coir on compressive strength, water absorption and volumetric change of adobe brick

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**Abstract** The adobe brick that made from soil in Chanthaburi province, Thailand was developed and combined with para rubber latex and coir for environmentally sustainable development. Water content was fixed at a ratio of 0.4 by weight of soil for all mixtures. This amount of water was suitable for mixing and molding of adobe brick. The para rubber latex was added to the traditional mixture at the ratios of 5, 10, 15, and 20 percent by weight of water, respectively. Coir was added as reinforcement of soil structureat 1.0 percent by weight of soil. The compressive strength, water absorption, and volumetric change of adobe bricks were investigated at the ages of 28 days. The results showed that the mixtures containing para rubber latex and no coir gave an outstanding property in dissolution resistance by water. All samples were remained in shape after 28 daysof water immersion. While the traditional mixture and mixtures with coirwere dissolved within 24 hours. Moreover, the mixture with 15 percent of para rubber latex gave the highest compressive strength, which was 1.58 MPa compared to 0.92 MPa of traditional adobe brick. It could be concluded that para rubber latex can improve compressive strength of adobe brick. In addition, it was found that mixture containing para rubber latexand coir showed lower volumetric change than the traditional adobe brick.

**Keywords:** Adobe brick, Para rubber latex, Coir

## Introduction

Environmentallysustainable development becomes a global issue, nowadays, due toenvironmental concerns. Around the world, several policies were togetherannounced for acknowledging this issue, for example, ASEAN declaration on environmental sustainability. These policies were declared to reduce the using of limited natural resources against the development of ASEAN countries. Constructionis one of the biggest industries that consume a lot of natural resources. For example, cement industry, the cement production is

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about 4000 milliontons per year and is expected to increase everyyear (Statista, 2018). Regrettably, it is not only cement industry but also another construction materials industry as well. Therefore, using of alternative green building materials is one possibility wayto conserve the limitednatural resources.

Earth construction is a traditional form of construction mostly found in dry climate regions. This type of construction has clear competitive advantages in the field of sustainability over conventional construction. The economic and environmental benefits, along with its properties, has been studied and reported (Adegun and Adedeji, 2017, Pacheco-Torgal and Jalali, 2012). Recently, in Thailand, earthen structure became to be famous because of ecotourism. Resort building made ofearthen structure is easily seen in natural tourist attractions. It is perfectly harmonized to the theme of ecotourism.

Adobe brick is an important construction material for earthen structure.However, adobe brick is used without acontrol standardwhich may cause of accident to people inside the building. Making of adobe brick in Thailand, nowadays, is based on personal knowledge and no standard for mix proportion and method. This results in variation ofquality of adobe brick, especially strength and durability. Normally, adobe brick composes of soil and water as main ingredients. Using different types of natural and/or synthetic fibers in soil reinforcement continues to be of interest. Researchers have reported that natural fibers improved compressive strength, stiffness and durability of adobe brick (Hejazi *et al.*, 2012, Vega *et al.*, 2011). Moreover, addition of natural fibers is more beneficial in terms of energy efficiency and health (Sharma *et al.*, 2015). Traditional adobe brick is, however, dissolved by water and natural fiber would not improve this issue. Promluangsri and Wongpa (2015) reported that using of asphalt emulsioncould decreasethe water absorptionof adobe brick. It resulted in service life extension of adobe brick, especially for outdoor using which always touch with watersplashing. However, asphalt emulsion is a chemical compound and non-environmentallyfriendly material. Therefore, it is notsuitable for environmentally sustainable development. Another rubber-like liquid is might be used instead of asphalt emulsion in similar manner.

In order to use natural materials as adobe brick mix ingredient for environmentally sustainability development, coir and para rubber latex were selected for this research. Since, coir is a natural fiber that easily find in local area of Chanthaburi province, Thailand. It has a high tensile strength and its physical shape is suitable for using as reinforcing fiber in brittle materials such as concrete (Yan *et al.*, 2015) and soil (Anggraini *et al.*, 2015). While para rubber latex is a natural rubber which is normally stretchy, flexible and waterproof (George *et al.*, 2014). Moreover, para rubber latex could be mixed with soil and use as pond surface to prevent the water seepage (Uniroyal Inc., 1972). To study this new developed adobe brick, compressive strength, water absorption, and volumetric change were observed and compared to traditional adobe brick. The results from this research would be used as a reference to develop a better adobe brick in the future which can be used for ecotourism with safety at the same time.

## Materials and methods

Soil, the major ingredient, was brought from aninterlocking brick factory within Chanthaburi province. The soil source of the factorycomes from a soil supply area in the province. As received soil was sieved by No.10 mesh (opening 2 mm) to obtain uniform soil particle size. A sample of soil was tested for Atterberg limits to determine liquid limit, plastic limit, and shrinkage limit. Experimental soil was classified using Unified Soil Classification System (USCS) as well-graded sand with silt (SW-SM). Properties of soil used in this research are shown in Table 1.

**Table1.** Properties of experimental soil

| Properties | Value |
|---|---|
| Liquid limit (%) | 59.78 |
| Plastic limit (%) | 49.96 |
| Shrinkage limit (%) | 13.06 |
| Spacific gravity | 2.71 |
| USCS | SW-SM |

Coir or coconut fiberhas been selected for used in this research since it is a local natural fiberand having superior structural stiffness (Ashik *et al.*, 2018). As received coir, its length and diameter were varied as shown in Figure 1.Higher aspect ratio (length/diameter) of fiber, easier balling problem(Ghanem and Obeid, 2015). Therefore, the coir has been shortened by cutting into 2-5 cm of length. Coir was mixed as adobe brick ingredient without any further treatment after cutting.

Para rubber tree (*H. brasiliensis*) is one of economic crops of Thailand and easily find in Chanthaburi province. However, para rubber latex, the product from *H. brasiliensis*, can not be used directly since the quality of the latex could not be controland it is rotten very fast. Therefore, commercial grade oflow ammonia–tetramethylthiuram disulfide/zinc oxide (LA-TZ) from D.S. Rubber & Latex Co., Ltd. wasused through this research.LA-TZ is one kind of concentrated latex available in the market which is preserved with low ammonia and other preservatives. TheLA-TZ contains, not less than, 60% of dry rubber content as the major composition. The properties of LA-TZ used in this study are shown in Table 2.

**Figure1**. As received coir before cutting

**Table 2.** Properties of para rubber latex

| Properties | Para rubber latex |
|---|---|
| Total Solid Content, TSC (% by weight) | 61.61 |
| Dry Rubber Content, DRC (% by weight) | 60.18 |
| Non-Rubber Content (% by weight) | 1.43 |
| Alkalinity on total weight (%$NH_3$) | 0.27 |
| pH Value at 25 °C | 9.65 |
| KOH number | 0.69 |
| Volatile Fatty Acid number (VFA No.) | 0.025 |
| Mechanical Stability Time @55% TSC (Seconds) | 969 |
| Magnesium Content on Solids (ppm) | 21 |
| Viscosity @Roto No. 60 RPM (cP) | 80 |
| Color of Latex | White |

For preliminary study, soil was mixed with various amount of water to identify the water content that would suitable for mixing and molding of adobe bricks. From an inspection by visual observation, the suitable amount of water was 40% by weight of soil which was used for all mixtures in this research.

There were three kinds of sample in this research namely; traditional adobe brick (Control), adobe brick with para rubber latex (L), and adobe brick with para rubber latex and coir (LC). Para rubber latex was used as an additional admixture in the mix proportion at the ratios of 5, 10, 15, and 20 percent by weight of water hereafter called as L5, L10, L15, and L20, respectively. Coir, after shortening, was added at the ratio of 1.0percent by weight of soil. Sincecoir was only added to mixtures containing para rubber latex. Therefore, the symbols would be showed by the letter “LC” following by latex content.For example, LC5 refers to a mixture containing 5% of latex and 1.0% of coir.

All mixtures were mixed following the mix proportionsas shown in Table 3. For control sample, soil and water were firstly hand-mixedtogetherin a plastic tray until atoothpaste-like homogeneous clay has been observed. Then, fresh clay was separatelycast in three types of steel molds. Cylindrical steelmold with 10 cm of diameter and 20 cm of height was used for casting samples of compressive strength testing. For water absorption and volumetric change testing, cubic shape with dimension of 5 cm each and rectangular shape with size of 4 x 4 x 16 cm were used, respectively. For L and LC sample, the mixing method is similar to control sample. Para rubber latex and coir were added one after the other into the fresh clay. All ingredients were mixed together until the homogeneous clay has been observed.While the molding of L and LC samples were totally the same of control sample.

**Table 3.** Mix proportions of adobe brick

| Mixture | Soil (kg) | Water (kg) | Para rubber latex (g) | Coir (g) |
|---|---|---|---|---|
| Control | 12.0 | 4.8 | 0 | 0 |
| L5 | 12.0 | 4.8 | 240 | 0 |
| L10 | 12.0 | 4.8 | 480 | 0 |
| L15 | 12.0 | 4.8 | 720 | 0 |
| L20 | 12.0 | 4.8 | 960 | 0 |
| LC5 | 12.0 | 4.8 | 240 | 120 |
| LC10 | 12.0 | 4.8 | 480 | 120 |
| LC15 | 12.0 | 4.8 | 720 | 120 |
| LC20 | 12.0 | 4.8 | 960 | 120 |

To prevent exceed air voids inside the sample, the fresh clay was separately placed into 5 layers. Since the fresh clay is toothpaste-like condition, tamping cound not be applied but softly pressed by hand to make sure that all clay-layer was placed, properly. Trowel was used to make a smooth surface of samples after placing all 5-layer. The samples were cured inside the molds in open air conditionunder a shade for 4days, then demolded. All samples were continuously cured in the same condition for another 28-day without molds, and then their compressive strength, water absorption, and volumetric change were investigated.

Compressive strength test of the samples wasdone by using compression testing machine with capacity of 100 tons. A thick rubber plate was placed on top of the samples to adjust their flatness while loading for preventing of error. Water absorption of a sample was investigated by calculating of massincreasing after 24-hour immerse in water. While volumetric change of a sample was observed by calculating of the difference between volumes of same sample before and after drying at 28 days. For all tests, the reported value of a mixture was an average value calculated from three samples. The samples for compressive strength test, water absorption test, and volumetric change test were shown in Figure 2(a), (b), and (c), respectively.


**Figure 2.** Samples for the tests of (a) compressive strength, (b) water absorption,and (c) volumetric change

**Results**

The results of compressive strength, water absorption, and volumetric changetests of 28 days-adobe bricks are summarized in Table 4.

***Compressive strength***

Compressive strength results of L series are plotted in comparison with those of LC series as shown in Figure 3. It was clearly found that para rubber latex dramatically improves compressive strength of adobe brick. The maximum compressive strength was found from L15 with 1.58 MPa or about 70% higherthan that of traditional adobe brick.

**Table 4.** Test results of adobe bricks

| Mixture | Compressive Strength (MPa) | Water Absorption (%) | Volumetric Change (%) |
|---|---|---|---|
| Control | 0.92 ±0.23 | N/A/1 | 20.00 |
| L5 | 1.33 ±0.02 | 31.42 ±0.90 | 21.89 |
| L10 | 1.48 ±0.22 | 31.96 ±1.36 | 22.80 |
| L15 | 1.58 ±0.07 | 27.72 ±1.36 | 22.98 |
| L20 | 1.51 ±0.05 | 26.76 ±0.50 | 24.08 |
| LC5 | 0.96 ±0.07 | N/A/1 | 15.30 |
| LC10 | 1.19 ±0.05 | N/A/1 | 15.41 |
| LC15 | 1.10 ±0.00 | N/A/1 | 18.15 |
| LC20 | 1.11 ±0.03 | N/A/1 | 18.92 |

1/Measurement could not be applied due to the damage of the sample

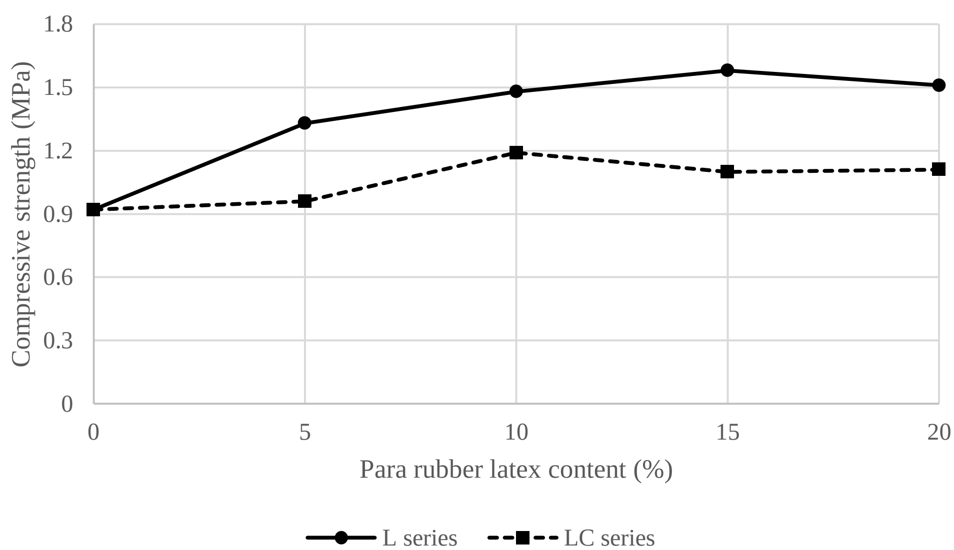


**Figure 3.** Compressive strength of adobe bricks containing para rubber latex (L series) and adobe bricks containing para rubber latex and coir (LC series)

### *Water absorption*

The samples after immersion in water for 24 hours was shown th Figure 4. It was clearly seen that mixtures with only para rubber latex can stay in shape after 24 hours of water immersion. In details, the damage on the sample is different between the samples of control and LC mixtures. All 3 samples of control mixture were completely collapsed whereas the in-plain fracture was found in LC samples. However, the whole body of LC samples were not collapsed but keep staying in shape.

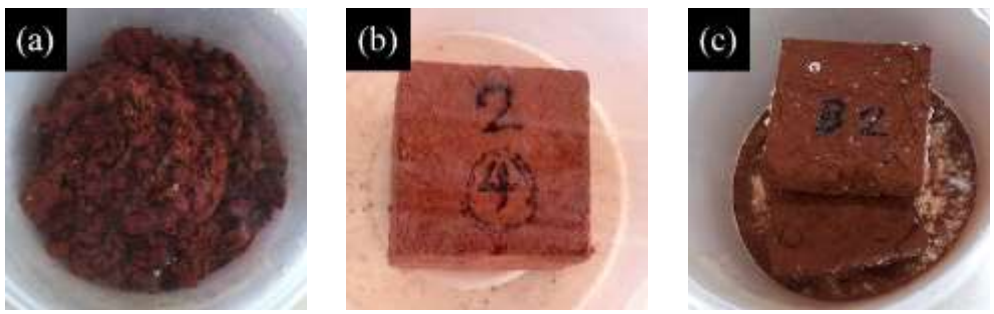


**Figure 4.** Samples after water immersion for 24 hours (a) Control mixture, (b) L mixture, and (c) LC mixture

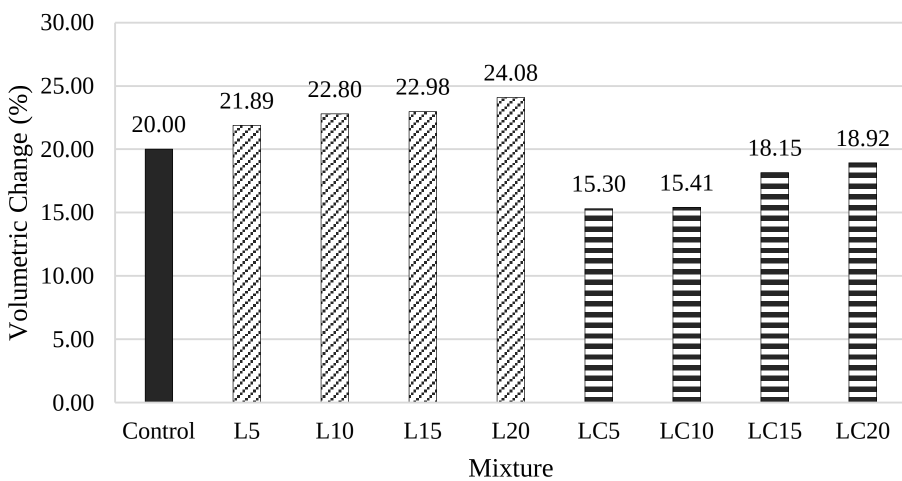


**Figure 5.** Volumetric change of adobe bricks

### *Volumetric change*

Volumetric change means the difference of volume between the original volume and volume at the age of 28-days of the same sample. From the results, it could be considered as shrinkage after drying. Then, higher value means higher shrinkage of the sample. The controlmixture was the average volumetric change of 20.00 percent (Fig.5). All mixtures containing para rubber latex without coir, the volumetric change is higher than the control one.

## Discussion

Compressive strength of adobe bricks increases with increasing latex content. This is due to the latex fills the voids and binds soil particles together. However, the latex itself is a rubber-like material which has a very low compressive strength. Therefore, using too much latex in the mixture will result in compressive strength reduction as can be observed from L20 mixture.In addition, it was found that adding of coir resulted in decreasing of compressive strength comparing to that of same mixtures without coir. It means that coir gives negative result to compressive strength of adobe brick. Yetgin *et al.* (2008) found a similar result and explained that the compressive strength decreased due to lower unit weight in higher fiber content mixture which can be used to explain for this research as well. In addition, coir is a kind of fiber which normally can not resist compressive force but tensile force. Furthermore, coir in the sample disturbs the cohesion between soil particles (Yokoi, 1968). Hence, compressive strength reduction was observed when coir was added to the L mixtures. However, all mixtures containing coir have a higher compressive strength than the traditional adobe brick with similar to a research (Hejazi *et al.*, 2012). In addition, all mixtures show a comparable compressive strength value to another researches (Danso *et al.*, 2015, Promluangsri *et al.*, 2017). Therefore, this could be said that it is possible to use soil in Chanthaburi province, Thailand, in making adobe brick.

After visual comparing the water absorption results of all 3 mixtures in Figure 4, it can be implied that para rubber latex improves the water resistance to the adobe brick, but coir breaks the sample from inside the body after soaking. The reason that can explain this phenomenon is that the coir absorp water. Since, coir can absorp the water as high as 130-200 percent (Danso *et al.*, 2015, Hejazi *et al.*, 2012), then it is possible to expand itself inside the brick's body. Together, the soil particles nearby the fiber will be weakened by water from osmosis and diffusion of water in fiber. Consequently, in a layer containing a specific amount of coirs, the expansion is high enough to break the brick out from inside into layers. Therefore, plain splitting can be observed. In case the expansion is not that high, crack will be observed as shown at the surface of the sample in Figure 4 (c). However, since the LC samples keep staying in shape, the para rubber latex is clearly state itself as a binding agent.

The mixtures with higher latex content showed higher volumetric change. This is because the latex contains about 40% of water and the latex is a rubber-like material, which is already well known. Therefore, large shrinkage will be observed after most water evaporated out of the sample, especially for the higher latex content.For all LC mixtures, containing both para rubber latex and coir, the volumetric change is lower than the traditional adobe brick. The similar result was also found and reported that natural fiber such, for example straw and coir, reduces the shrinkage of adobe brick or brick that made from soil (Danso *et al.*, 2015, Hejazi *et al.*, 2012). Because, it has friction force at the surface between soil particle and fiber (Anggraini *et al.*, 2015) with refers to a study conducted by Harianto *et al.* (2009). This force tries to prevent the movement of soild particles results in lower shrinkage, consequently.Hence, it can be implied that coir helps in volume stability of adobe brick.

In this research, nine mixtures were made namely; traditional adobe brick, adobe bricks with para rubber latex, and adobe bricks with para rubber latex and coir. It could be concluded that it is possible to make adobe brick from soil in Chanthaburi province, Thailand, and its compressive strength is about 1-1.5 MPa which is enough for normal using. Para rubber latex is possible to use as adobe brick admixture to improve water resistance and thus significantly increase service life of traditional adobe brick. However, para rubber latex content of 15% by weight of water is recommended since it shows the highest compressive strength. Coir helps in volume stability of adobe brick. Moreover, it is showed that adding coir of 1.0% by weight of soil resulted in the dramatically decreased of volumetric change for all samples, significantly. However, coir reduces water resistance behavior of para rubber latex in adobe brick. The expansion of coir fiber and water osmosis, the sample were cracked or splitted into layers.

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## References

Adegun, O. B. and Adedeji, Y. M. D. (2017). Review of Economic and Environmental Benefits of Earthen Materials for Housing in Africa. Frontiers of Architectural Research. 6:519-528.

Anggraini, V., Asadi, A., Huat, B. B. K. and Nahazanan, H. (2015). Effects of Coir Fibers on Tensile and Compressive Strength of Lime Treated Soft Soil. Measurement. 59:372-381.

Ashik, K. P., Sharma, R. S. and Guptha, V. L. J. (2018). Investigation of Moisture Absorption and Mechanical Properties of Natural /Glass Fiber Reinforced Polymer Hybrid Composites. Materials Today: Proceedings. 5:3000-3007.

Danso, H., Martinson, D. B., Ali, M. and Williams, J. B. (2015). Physical, Mechanical and Durability Properties of Soil Building Blocks Reinforced with Natural Fibres. Construction and Building Materials. 101:797-809.

George, U. U., Andy, J. A. and Joseph, A. (2014). Biochemical and Phyto -Chemical Characteristics of Rubber Latex (Hevea Brasiliensis) Obtained from a Tropical Environment in Nigeria. International Journal of Scientific & Technology Research. 3:377-380.

Ghanem, H. and Obeid, Y. (2015). The Effect of Steel Fibers on the Rhyological and Mechanical Properties of Self Compacting Concrete. European Scientific Journal. 11:85-98.

Harianto, T., Hayashi, S., Du, Y. and Suetsugu, D. (2009). Geosynthetics in Civil and Environmental Engineering. Springer. 421-442.

Hejazi, S. M., Sheikhzadeh, M., Abtahi, S. M. and Zadhoush, A. (2012). A Simple Review of Soil Reinforcement by Using Natural and Synthetic Fibers. Construction and Building Materials. 30:100-116.

Pacheco-Torgal, F. and Jalali, S. (2012). Earth Construction: Lessons from the Past for Future Eco-Efficient Construction. Construction and Building Materials. 29:512-519.

Promluangsri, P. and Wongpa, J. (2015). A Development of Adobe Brick Made from Loess. The 20th National Convention on Civil Engineering. 8-10 July 2015:1-7.

Promluangsri, P., Wongpa, J. and Raungrut, C. (2017). A Study on Properties of Adobe Brick Mixed with Asphalt Emulsion under Continuous Submergence Condition. Rajabhat Rambhai Barni Research Journal. 11:130-138.

Sharma, V., Vinayak, H. K. and Marwaha, B. M. (2015). Enhancing Compressive Strength of Soil Using Natural Fibers. Construction and Building Materials. 93:943-949.

Statista (2018). Cement Production Globally and in the U.S. From 2010 to 2017 (in Million Metric Tons). Retrieved from https://www.statista.com/statistics/219343/cement-production-worldwide/.

Uniroyal Inc (1972). Use of Latex as a Soil Sealant to Control Acid Mine Drainage. U.S. Environmental Protection Agency, Water Pollution Control Research Series 14010 EFK 06/72:90P.

Vega, P., Juan, A., Ignacio Guerra, M., Morán, J. M., Aguado, P. J. and Llamas, B. (2011). Mechanical Characterisation of Traditional Adobes from the North of Spain. Construction and Building Materials. 25:3020-3023.

Yan, L., Su, S. and Chouw, N. (2015). Microstructure, Flexural Properties and Durability of Coir Fibre Reinforced Concrete Beams Externally Strengthened with Flax Frp Composites. Composites Part B: Engineering. 80:343-354.

Yetgin, Ş., ÇAvdar, Ö. and Çavdar, A. (2008). The Effects of the Fiber Contents on the Mechanic Properties of the Adobes. Construction and Building Materials. 22:222-227.
Yokoi, H. (1968). Relationship between Soil Cohesion and Shear Strength. Soil Science and Plant Nutrition. 14:89-93.

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