On the mechanical properties of para rubber-oil palm ash derived geosynthetic clay liner

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Abstract. A mixture of kaolinite and oil palm ash with latex binder were from to make a core of the geosynthetic clay liner. Then, it was covered by latex-coated calico. The GCL developed had the width and length of 100 cm and 200 cm, with the total thickness of about 7 mm. It is to be used as liner at the bottom of a landfill in order to prevent the leachate to have a contact with the groundwater that could harm people who make use of that contaminated water. Several laboratory tests were carried out to evaluate whether it has the same properties as commercial ones; and, it can be employed in field. Only punching shear resistance and tensile strength are reported in this paper. It was found that both tests yield results that are in accordance with the industrial standard, indicating that it can be really employed in the field.

1. Introduction
Para rubber and oil palm are ones of the most important crops in Thailand, especially in the South. The price for the former has progressively decreased over the years, resulting in the economic problem countrywide. The latter has been in a similar situation, but in a lesser extent. The associated problem is that, however, ashes left from manufacturing processes have caused air pollution that requires a solution to improve the environment. The production of natural para rubber in Thailand has steadily increased from 3.12 million tonnes in 2006 to 4.47 million tonnes in 2015 [1]. Of the total production of 4.47 million tonnes, 3.75 million tonnes were exported, while only 0.60 million tonnes were domestically consumed. From these figures, no doubt that why it is very important to Thailand in terms of economy. The oil palm production in Thailand has as well gradually increased from 3.3 million tonnes in 2000 to 12.5 million tonnes in 2014; and, it has been forecast to be 19.2 million tonnes in 2022 [2]. It can be seen that the crop is so vital for the economy of the country, as high as for the para rubber. As such, when the price for both crops goes down, it is important for policy makers to improve the situation. Researchers are one of the key players that could find solutions in order that make them value added. In Thailand, dumping waste in unprotected hole is not abnormal. This practice leads to environmental
problems somewhat [3]. For instance, the leachate could have a contact with the groundwater thereby causing it contaminated. People who have utilised that water will surely suffer. As a result, this study attempted to develop a geosynthetic clay liner (GCL) derived from para rubber and oil palm ash. Note that the GCL is employed at the bottom and sides of a landfill in order to prevent the leachate to flow through and contaminate the groundwater as a consequence. The GCL was made according to figure 1: it comprises top and bottom layers made from calico coated with latex compound and the internal core made from the mixture of artificial clay, oil palm ash, and latex compound. This creates an almost impermeable layer that could prevent the flowing of leachate generated from the waste.

![Figure 1. Proposed GCL made from clay, oil palm ash, and para rubber.](image)

2. Experimental
Normally, bentonite is used as core of the GCL. In this case, kaolinite was chosen instead. This is because bentonite must be imported, while kaolinite can be obtained from a mine in Southern Thailand. Please be noted that bentonite is normally employed because it has lower permeability. The oil palm ash in this study was obtained from Krabi. The latex compound was prepared using the following ingredients: 60% HA latex, 10% KOH, 20% K-oleate, 50% ZDEC, 50% Wing stay L, 50% sulphur, 75% CaCO₃, 15% carbon black, and 50% ZnO. Figure 2 displays the kaolinite and oil palm ash employed; figure 3 shows how the latex compound was developed.

![Figure 2. Kaolinite (a) Oil palm ash (b)](image)

![Figure 3. Preparation of latex compound (a) and (b), adding carbon black to the compound (c)](image)
To develop the GCL, first the coated calico was made according to the procedures shown in Figure 4. The bottom sheet then was laid on a flat floor; the compound latex was sprayed over. Next, the mixture of clay and OPA was laid over; and, the compound latex was sprayed over. After the top sheet was placed to cover, making a mixture sandwiched by the two sheets. To make it moveable, the GCL was manually sewed. To be able to use the GCL many tests were carried out. These include (1) permeability of the core, (2) punching shear resistance of the sheet, and (3) tensile strength of the sheet. In this paper, only the strengths were reported and discussed.

3. Results and discussion
The important properties for GCL are an ability to withstand both punching shear and axial shear forces. It should be noted that calico and geotextile (normally used to cover the GCL) are very different in terms of texture and manufacturing processes. The latter is developed specifically to withstand those forces; while the former is made for totally different purposes. That is why the geotextile is employed to assembly the GCL.

A total of 10 samples were employed for both punching shear and axial shear tests in order to obtain an average value. Table 1 displays the results obtained from punching shear test. The average value showed that it can withstand up to 2235 N (equivalent to 228 kg force). According to the standard set for the GCL, it states that the minimum required punching shear is 600 N. This result shows that the material used in this study is more than enough. In other words, thinner calico may be employed thereby reducing the cost of manufacturing. From the tensile test, it was found that the averaged value from 10 testes is 2832 N. Comparing this figure to the value set by the industrial standard of 2000 N, it can be seen that, again, the material has more than enough tensile strength to withstand the force during construction.
Table 1. Punching shear resistance of the coated calico

| Sample no. | Area (sq.m) | Weight (g) | Punching force (N) |
|------------|-------------|------------|--------------------|
| 1          | 0.0625      | 33.55      | 2100               |
| 2          | 0.0625      | 35.64      | 1950               |
| 3          | 0.0625      | 33.55      | 2800               |
| 4          | 0.0625      | 35.64      | 2650               |
| 5          | 0.0625      | 33.55      | 1850               |
| 6          | 0.0625      | 35.64      | 2750               |
| 7          | 0.0625      | 33.55      | 1900               |
| 8          | 0.0625      | 35.64      | 2350               |
| 9          | 0.0625      | 33.55      | 1950               |
| 10         | 0.0625      | 35.64      | 2050               |

Average punching force: 2235

Table 2. Tensile strength of the coated calico

| Sample no. | Max. tensile force (N) | Max. elongation (mm) |
|------------|------------------------|----------------------|
| 1          | 2433                   | 34.07                |
| 2          | 2373                   | 33.77                |
| 3          | 2439                   | 33.68                |
| 4          | 2673                   | 38.84                |
| 5          | 2708                   | 33.47                |
| 6          | 3068                   | 41.26                |
| 7          | 3151                   | 41.86                |
| 8          | 3451                   | 47.85                |
| 9          | 2303                   | 32.27                |
| 10         | 3722                   | 49.48                |

Average: 2373

4. Conclusions
This study attempted to find a new means for making use of para rubber and oil palm ash. The development of GCL was chosen to achieve the determination. Artificial clay was mixed with the OPA and latex binder to form a core of the GCL. The, it was covered with latex-coated calico, both sides. Several laboratory tests were carried out in order to evaluate its properties. In this paper, it was found that both punching shear and tensile strength of the GCL developed is in accordance with the standard, indicating that it can be employed in the field.

5. References
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