Utilization of overcured natural rubber latex compound in modified concrete manufacturing

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Abstract. Overcured natural rubber latex compound has always become a waste and should be discarded, which is a problem to the environment. Thus, the latex compound waste is used as an alternative material in modifying concrete product. Latex waste is mixed with other materials, such as cement, fine aggregate, hard aggregate, and water. Series of modified concrete is made with variation of the composition of latex waste by 0%, 2%, 4%, 6%, 8%, and 10% of the weight of the cement used. The concrete mixture is then poured into a cylindrical mold with dimensions of 15x30 cm (in accordance with ASTM C39 standards) and cured for period of 28 days. The products of modified concrete have been tested with according standards and the results show that the addition of overcured natural rubber latex compound can reduce the concrete density, reduce its absorption ability and increase the mechanical strength of concrete.

1. Introduction
Concrete is a composite material consisting of cement as matrix and aggregate as filler that functions as a reinforcement with the addition of other ingredients [1]. However, the concrete that is produced using cement has many weaknesses, some of which are high concrete moisture, vulnerable to moss attack which could increase concrete brittleness, and the fact that cement producing process creates CO2 that could pollute the environment [2]. Therefore, concrete industries have considered using industrial by-products or wastes as concrete additives. One of the additives that is used in this research is waste natural rubber latex. The waste latex is formed when natural rubber latex undergoes an excessive curing through the pre-vulcanization process and thus becomes overcured. This overcured latex is usually disposed of and becomes waste because of its bad properties [3]. However, waste natural rubber latex contains high-quality rubber hydrocarbons which is formed through cross-linking process, in which it binds rubber molecular chains so that mixing those involves the hydrocarbons can improve the product mechanical properties and its porosity [4]. Information about the utilization of waste natural rubber latex on concrete has not yet established and there is no known effect presented by the addition of waste natural rubber latex on concrete. The lack of its applications has thus become the basis to investigate waste natural rubber latex effect on concrete manufacturing.

2. Methods
2.1 Materials
Portland Cement, Waste natural rubber latex, gravel, and sand are obtained from shops around the city of Medan, North Sumatera, Indonesia. Water is obtained from the Concrete Laboratory, Department of Civil Engineering, Faculty of Engineering, Universitas Sumatera Utara, Medan, Indonesia.

2.2 Overcured Natural Rubber Latex Waste
Natural rubber latex undergoes the pre-vulcanization process for 30 minutes at 70°C to form an overcured natural rubber latex waste.
2.3 Concrete Manufacturing
Portland cement, gravel, and sand that has been weighed according to the composition in Table 1. and mixed using concrete mixer. Then, overcured latex and water is added, stirred until evenly mixed. After that, the mixture is poured into a cylindrical mold with dimensions of 15x30cm for the next 24 hours and then cured in water for 28 days.

| Overcured Lates Variations (m/m) | Overcured Latex | Cement | Fine Aggregates | Hard Aggregates | Water |
|---------------------------------|----------------|--------|-----------------|-----------------|-------|
| 0%                              | -              | 2.07   | 4.76            | 6.99            | 1.13  |
| 2%                              | 0.04           | 2.03   | 4.76            | 6.99            | 1.13  |
| 4%                              | 0.08           | 1.99   | 4.76            | 6.99            | 1.13  |
| 6%                              | 0.12           | 1.95   | 4.76            | 6.99            | 1.13  |
| 8%                              | 0.17           | 1.90   | 4.76            | 6.99            | 1.13  |
| 10%                             | 0.20           | 1.87   | 4.76            | 6.99            | 1.13  |

3. Result and Discussion
3.1 Physical Properties Test
3.1.1 Density
Concrete density test was carried out in accordance with SNI 03-6433-2000, in which the effect of overcured natural rubber latex compound on concrete density is shown in Figure 1. The result shows that the density of concrete decreases along with the increasing percentage of overcured latex. The reason of the decrease in density is because of the substitution of cement with the overcured latex. Concrete density is determined by the density of each of its constituent, while cement has the highest density among other constituents in concrete [6]. By substituting overcured latex which has lower density, it could reduce the whole concrete density. Overcured latex tendency to agglomerate also contribute to the concrete density [5], which could prevent the overcured latex to fill in the concrete cavities.

![Figure 1. Effect of Overcured Natural Rubber Latex Waste on Concrete Density](image)

3.1.2 Absorption
Concrete absorption test is carried out in accordance with SNI 03-6433-2000, in which the effect of overcured natural rubber latex compound on concrete absorption is shown in Figure 2. The figure shows that with the addition of 2% overcured latex, the absorption value decreased. However, the addition above 2% of overcured latex increase the concrete absorption. The decrease in absorption value when added overcured latex of 2% is due to the nature of the hydrophobic latex [7]. Overcured latex can also form a thin matrix layer surrounding the aggregate and cover its porosity. Overcured
latex also contains zinc oxide compounds which could improve the concrete water resistance [8], so that absorption of water in the aggregate can be reduced. With the reduced absorption in aggregates, the absorption of the whole concrete is also decreased and will affect the compressive strength of the concrete as well [9].

However, along with the increasing percentage of overcured latex above 2%, the absorption value of the concrete increases. This mainly caused by the overcured latex tendency to agglomerate [5]. Because of this particular nature, overcured latex compound becomes difficult to spread through the concrete and cannot fill the cavaties in concrete as expected from which water can enter the cavaties.

![Figure 2](image2.png)

**Figure 2.** Effect of Overcured Natural Rubber Latex Waste on Concrete Water Absorption

### 3.2 Mechanical Properties Test

#### 3.2.1 Compressive Strength

Concrete compressive strength test is carried out in accordance with SNI 03-6805-2002 in which the effect of overcured natural rubber latex compound on concrete compressive strength is shown in Figure 3. The figure shows that when the concrete compressive strength is increased with the addition of overcured latex by 2%. However, with the addition that exceeds 2%, the compressive strength decreases. The reason over the increasing compressive strength by the addition of 2% is due to the ability of overcured latex to spread along and cover the concrete cavities which is also indicated by the low absorption value that can be seen through the absorption analysis in Figure 2. Futhermore, the overcured latex contains sulfur particle which can help improving the mechanical properties of concrete [8]. However, the compressive strength decreases as the percentage of overcured latex increases above 2%. This is because the nature of the latex compound which tends to agglomerate resulting in weakening the bond between the aggregates [5].

![Figure 3](image3.png)

**Figure 3.** Effect of Overcured Natural Rubber Latex Waste on Concrete Compressive Strength

#### 3.2.2 Split Tensile Strength

Concrete split tensile strength test was carried out in accordance with SNI 03-1974-2011 in which the effect of overcured natural rubber latex compound on concrete products on split tensile strength is shown in Figure 4. The figure shows that the value of split tensile strength increased from 2.46 MPa to
2.7 MPa when the percentage of the overcured latex ranges from 2% to 4%, then the split tensile strength will decrease subsequently as the percentage of overcured latex increases.

The increasing value of split tensile strength by the addition of overcured latex up to 4% is due to the elastic properties that is possessed by the latex compound waste and the presence of sulfur content from the pre-vulcanization process which can improve its mechanical properties [8]. Despite the existence of these properties, the addition of overcured latex that exceeds 4% could decrease the concrete split tensile strength. This is due to the tendency of latex compounds to agglomerate rapidly upon mixing [5]. These lumps can reduce the bond between cement and aggregate and between the aggregate itself, which could reduce the concrete split tensile strength.

Generally, every efforts that is being done to improve the quality of the concrete compressive strength is not always followed by the improvement of the split tensile strength [10]. In Figure 3. It can be seen that by the addition of 4% of overcured latex, the compressive strength of the concrete decreases, the split tensile strength increases. This is due to the fact that normally, concrete is consisted of several small smooth cracks, where these smooth cracks do not have a large effect on the compressive strength. It is because when the concrete receives pressure, the pressure is then distributed through the whole body of the concrete which could close up the smooth cracks. While on the other hand, concrete split tensile strength is greatly affected by the intensity of this smooth cracks [10].

![Figure 4](image)

**Figure 4.** Effect of Overcured Natural Rubber Latex Waste on Concrete Split Tensile Strength

### 4. Conclusion

The addition of overcured natural rubber latex compound with a percentage of 2%-4% is capable of replacing cement in concrete. However, when the addition exceeds those percentages, the quality of the produced concrete will fall off. This can be seen from the physical and mechanical properties test results, where the best results from absorption and the compressive strength is at the addition of 2% while the split tensile strength is at the addition of 4%.

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