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EXPERIMENTAL STUDY ON STRENGTH OF GEOCOMPOSITE WALL FROM LIME STABILIZED CLAY ACTIVATED BY ALKALINE AND EXPANDED POLYSTERENE (EPS)

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ABSTRACT

Industrial plastic waste such as expanded polystyrene is very difficult to decompose naturally, this will have a global environmental impact. Large amount of Expanded Polystyrene (EPS) industrial waste is a major problem in environmental pollution. This study aims to make a geocomposite wall panel consisting of a mixture of clay, activator and expanded polystyrene (EPS) and to determine the physical and mechanical properties as well as the flexural strength capacity of the clay geocomposite panel. This research is focused on the development of soil composites made by mixing shaved EPS with quicklime stabilization clay soil activation of resin and iron oxide with the Static Compaction Method based on volume ratios. EPS content of 40%, 50%, and 60%. Activator 20% for dry bulk weight and optimum moisture content. The material performance was analyzed by testing the composite material which included the flexural strength. Results show addition of EPS makes the flexural strength value decrease because the addition of EPS reduces the density value so that the stiffness of the soil decreases even though there is an activator.

Keywords: Expanded Polystyrene (EPS), Clay, Lightweight material, Flexural Strength

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1. INTRODUCTION

Global concern about the environmental impact of waste disposal and the strict application of environmental laws led to a great deal of research on recycled materials. Increased awareness about the engineering value of waste materials, lack of landfill sites, and strong demand for construction materials have prompted research on composite materials, which are made entirely or partially from recycled materials. This trend is particularly strong in transportation and geotechnical projects, where large quantities of raw materials are typically used [1, 2].

The rapid development of technology has an impact on increasing human needs in all special fields in the field of civil engineering construction, thus encouraging researchers to carry out various studies to meet these needs [3, 4]. Until now, researchers have tried various alternative materials to meet construction needs.

Plastic waste is the biggest environmental problem because the material is not easily broken down by nature, either by rainfall and sun heat or by soil microbes. Because they are lightweight, plastics tend to rise to the surface when stockpiled, polluting the surrounding environment. If spilled in water bodies, plastic tends to clog the flow. when burned, it will cause smoke that is harmful to the environment and human health. Thus the increasing need for plastic raw materials, this waste will cause a very big problem [5 - 8].

One of the efforts to reduce the weight of the panel wall itself is to replace coarse aggregate with styrofoam (another name for expanded polystyrene plastic. The use of Expanded Polystyrene waste can be done by reusing. This is reflected in Japan, which uses EPS. quite a lot but 90% of the EPS used is recycled [9 - 15].

Soils in lowlands generally consist of fine sedimentation containing clay. To build infrastructure with certain specifications is faced with two alternatives, namely replacing bad soil or repairing existing soil so that it can meet the required specifications, one of which is by carrying out soil stabilization. Soil stabilization using stabilizers has been done and developed, both those that have been applied in the construction of civil engineering infrastructure and the results of scientific research that have not been applied. Materials that have long been used are Portland cement, lime, and bitumen. Stabilization with cement is suitable for non-cohesive soils, whereas lime and pozzolan are suitable for cohesive soils [16–22].

By utilizing a lot of expanded polysterene waste, a study was conducted using expanded polystyrene as a light aggregate in a stabilization mixture of clay, quicklime (CaO), resin resin ($C_{30}H_{50}O$) and ferrous oxide (Fe_2O_3). The resulting panel walls are classified as lightweight panel walls that can be used as room partitions, as a substitute for brick walls in high-rise buildings or as the main structure of a building with certain conditions that must be met. This research is expected to be an alternative use of waste or residual materials as construction materials.

2. MATERIAL AND METHOD

2.1. Physical and Mechanical Characteristics of Soil

The basic soil properties and the basic mechanical properties of the soil are the initial parameters that must be analyzed before the soil gets further treatment. Soil repair or stabilization methods differ for each type of soil. Therefore, in a research, a gradual basic analysis is needed to achieve the ideal stabilization method. The results of testing the physical and mechanical characteristics of the soil are shown in Table 1.

Based on the results of laboratory analysis of the soil as the basic material for making panels as shown in the results of the sieve analysis test, it was obtained that more than 50% of the soil passed the No. 200, which means the soil is fine-grained. Then the liquid limit value is 43.15% and the plasticity index is 26.40% in the atterberg limits test, based on the USCS (Unified Soil Classification System) classification system. By connecting the liquid limit value with the plasticity index on the plasticity diagram, the soil type is classified as CL (clay with low plasticity) which means clay with low plasticity.

Table 1 Physical and mechanical characteristics of soil

Kinds of Testing		Test Results	
		Value	**Unit**
Basic Properties of Soft Soil :			
Initial Water Content (w)		12.13	%
Specific Gravity (Gs)		2.65	-
Sieve Analysis and Hydrometer :			
a.	Sand	28.83	%
b.	Silt	17.87	%
c.	Clay	53.30	%
Atterberg Limits :			
a.	Liquid Limit (LL)	43.15	%
b.	Plastic Limit (PL)	16.75	%
c.	Plasticity Index (PI)	26.40	%
Standard Proctor :			
a.	Maximum Dry Density, (γd)	14.10	kN/m³
b.	Optimum Moisture Content (OMC)	30.13	%
Classification According USCS : CL			
Engineering Properties of Soft Soil :			
Unconfined Compressive Strength (qu)		47.35	kN/m²

2.2. Activator in the Stabilization Process

The activator used in this study is the optimum composition design from previous studies with a mixture of quicklime, resin resin and iron oxide (feroxide). Limestone (lime stone) $CaCO_3$ is activated to quicklime (CaO). The resin used is in the form of chunks of resin which are ground into resin resin ($C_{30}H_{50}O$). The iron oxide used is iron oxide red packaged with the chemical formula Fe_2O_3. The materials are then crushed so that they pass through a 100 sieve (size 0.150 mm). Reactivation of the stabilizing material is strongly influenced by the degree of fineness of the grains [20, 22].

2.3. Expanded Polystyrene (EPS)

Expanded Polystyrene is a polymer foam material which is generally known as Styrofoam. The content is 98% air and the rest is styrene compounds. This material is mostly used as an ingredient in the packaging of electronic products, glassware, and food packaging materials. Apart from being lightweight, polystyrene also has the ability to absorb very little water (watertight) below 0.25% [10 - 12].

2.4. Research Design

Preparation of the specimen material was carried out by mixing quicklime stabilization clay with activated resin resin and iron oxide with expanded polymerene (EPS). The addition of water to this mixing process is based on the optimum water content obtained from the results of soil compaction and activator.

Geocomposite panel samples were printed using a static compaction method based on a volume ratio with the content of Expanded Polystyrene (EPS) on the panels of 40%, 50% and 60%. The activator is 20%, the sample ripens for 7, 14, and 28 days, so that the clay and activator can react well so that it can bind shaved Expanded Polystyrene (EPS). Table 2 shows the composition of the geocomposite panels.

Table 2 Geocomposite panel composition

Activator (%)	Expanded Polysterene (%)	Ageing (Days)
20	40	7, 14 and 28
20	50	7, 14 and 28
20	60	7, 14 and 28

2.5. Flexural Strength Test

Ripening of panel samples to analyze the effect of time on increasing the flexural strength of panel samples based on SNI 4431: 2011 [23]. Panel samples were made in a box with a height of 5 cm and a length of 40 cm and a width of 40 cm. Figure 1 shows the dimensions of the flexural strength test panel. Figure 2 shows the process of testing the flexural strength of a geocomposite panel.

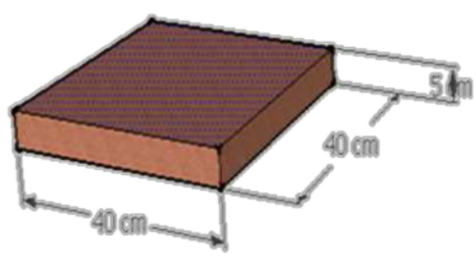

Figure 1 Flexural strength test panel dimensions

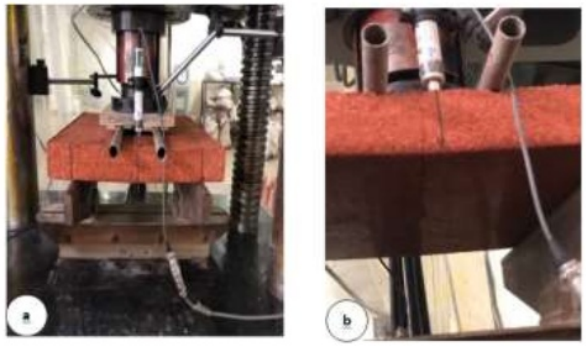

Figure 2 The process of testing the flexural strength of geocomposite panels. (a) Flexural strength testing with 2 points of loading. (b) Geocomposite panels after testing

The loading is carried out at a rate ranging from 8 kg/cm^2 - 10 kg/cm^2 per minute. The loading speed is reduced at the time before fracture which is indicated by the speed of the needle on the slow load scale, to avoid shock. After the sample experienced failure, the cracks were measured to the nearest 0.25 mm.

3. RESULTS AND DISCUSSION

The following is a graph of the flexural strength value of EPS-soil stabilization of quicklime, activation of resin resin and ferrous oxide on the spacing period, namely 7, 14, and 28 days. The tested specimens were compositions with the highest modulus and compressive strength values, therefore the composition of 20% activator with variations in EPS and yielding mass was chosen. Figure 3 shows the flexural strength curve of the geocomposite panel specimen with 20% activator 40% EPS.

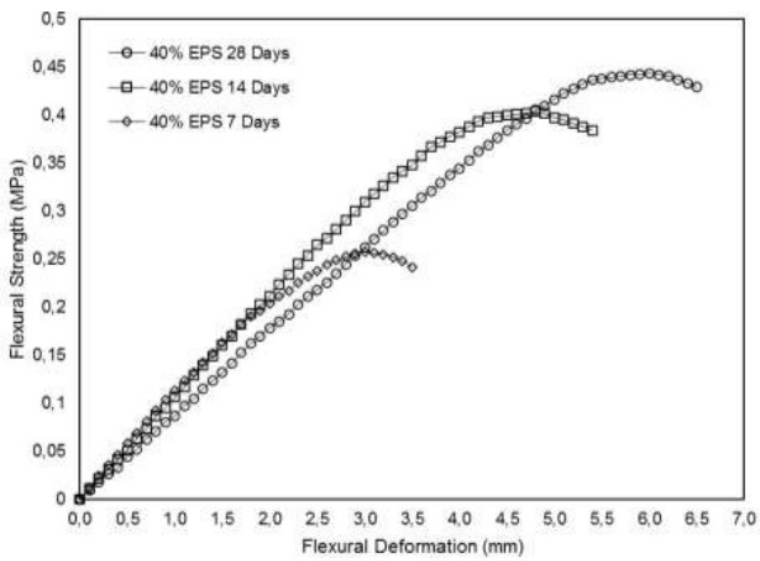

Figure 3 The flexural strength curve of the geocomposite panel specimen with 20% activator 40% EPS

In Figure 3, it is shown that the increasing the spacing mass, the higher the bending strength value. In a composition with 40% EPS and a period of 7 days, the flexural strength value is

0.258 MPa. During the 14-day period, the flexural strength value increased by 0.4036 Mpa. Meanwhile, at 28 days the flexural strength value increased until it reached 0.4436 MPa. Figure 4 shows the flexural strength curve of the geocomposite panel specimen with 20% activator 50% EPS.

In Figure 4, it is shown that the increasing the spacing mass, the higher the bending strength value. In a composition with 50% EPS and a period of 7 days, the flexural strength value is 0.252 MPa. At 14 days the flexural strength value increased by 0.3972 MPa. Meanwhile, at 28 days the flexural strength value increased to 0.4380 MPa. When compared with the EPS composition of 40%, the flexural strength of the specimen is 50% lower. This again refers to the results of the compressive strength test where the flexural strength value decreases with increasing EPS due to reduced density values and more pores. Figure 5 shows the flexural strength curve of the geocomposite panel specimen with 20% activator 60% EPS.

In Figure 5, it is shown that the increasing the spacing mass, the higher the bending strength value. In a composition with 60% EPS and a period of 7 days, the flexural strength value is 0.2488 MPa. During the 14-day period, the flexural strength value increased by 0.3944 Mpa. Meanwhile, at 28 days the flexural strength value increased to 0.4356 MPa. When compared with the EPS composition of 40% and 50%, the flexural strength of a specimen with 60% EPS is lower. This again refers to the results of the compressive strength test where the flexural strength value decreases with increasing EPS due to reduced density values and more pores.

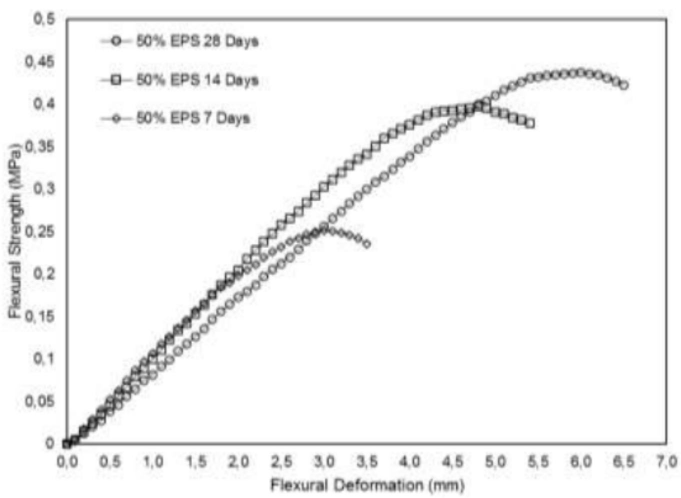

Figure 4 The flexural strength curve of the geocomposite panel specimen with 20% activator 50% EPS

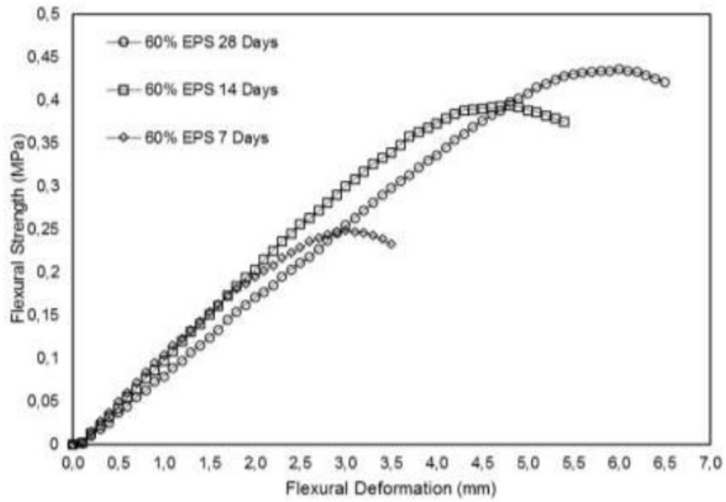

Figure 5 The flexural strength curve of the geocomposite panel specimen with 20% activator 60% EPS

Figure 6 shows the flexural strength value of EPS-soil stabilization of quicklime activation of resin resin and ferrous oxide. It can be seen that the increasing the spacing period, the higher the flexural strength value. However, as the EPS increases, the flexural strength value will decrease. This is because the number of pores in the panel increases with increasing EPS and reducing the density value, so that the stiffness of the soil decreases even with the presence of an activator.

The process that occurs shows that in an ideal clay particle, the positive and negative charges are in a balanced position, then isomorph substitution occurs and continuity of the arrangement breaks, so that a negative charge occurs on the surface of the clay crystal particles. One way to offset the negative charge, clay particles attract a positive charge (cation) from the salt in the pore water. This is called ion-exchange.

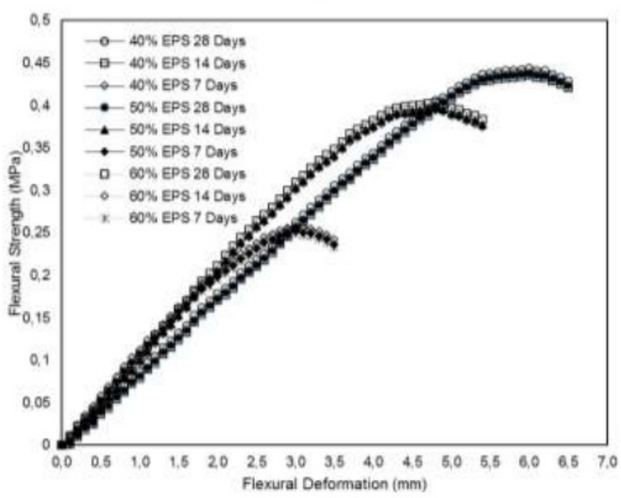

Figure 6 Flexural strength values of EPS-soil stabilization of quicklime activation of resin resin and ferrous oxide

4. CONCLUSION

Based on the results of the analysis in this study, the following conclusions were obtained:

1. From the results of testing the physical characteristics of the original soil, it is obtained according to the USCS (Unified Soil Classification System) by connecting the liquid limit value with the plasticity index on the plasticity diagram, the soil type is classified as CL (clay with low plasticity) which means clay with plasticity low.
2. The more the spacing period, the higher the flexural strength value. However, as the EPS increases, the flexural strength value will decrease.

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