The potential of styrogravel concrete as a new concrete material for building structures

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Abstract. Styrogravel concrete is a new-composite concrete made of a mix of styrogravel as a material replacing natural gravel. Styrogravel is a new material resulted from a simple chemical reaction of Styrofoam which is gravel-alike. The making process of the styrogravel is the same as that of conventional gravel. The method can be used as comparison of the solidity of the styrogravel in mechanical laboratory testing. The results of the study show that styrogravel concrete as a new concrete material is proven to be lighter yet stronger in comparison to conventional gravel. In terms of elasticity, styrogravel is proven to be better in deformation. Finally, in terms of axial elasticity, styrogravel is proven to be better when reaching high stretch.

1. Introduction
Styrogravel concrete is a new building material functioning as a substitute or combination of natural gravel. It is chosen since its basic characters are light, floating, strong, solid to heavy load and abrasion, not broken when having maximum weight, absorbing, and easy to form. It is considered easy since the basic material is Styrofoam waste which, through a simple chemical reaction, is shaped into granular looking like natural gravel with adjustable surface texture. The surface texture is a sticking medium between the surface and the cement paste. The basic characters of styrogravel, which are light, strong, and not brittle, are a strength in comparison with those of natural gravel which are heavy and brittle.

It is well-known that the composite characters of concrete depend on the characters of the shaper materials so that they will impact each other. The condition of the existing concrete has been proven to be heavy, brittle, having bad tensile strength and strong thrust, even though it shows good solidity. Ideally, it is expected that there is innovation in the concrete technology so that new materials with low specific gravity, with no brittle, and with good tensile strength, in addition to having good strength with the existing concrete and utilizing eco-friendly materials. Thus, styrogravel is expected to cover up the disadvantages of the existing concrete, particularly to create better performance of the gravel. Specifically, styrogravel is expected to have characters adjusting to its shaper materials, which are cement and grit.

The sole purpose of styrogravel concrete is to identify its potentials so that it can reduce the disadvantages of the existing concrete. In addition, it is also aimed to reduce the dangerous damage of Styrofoam waste through the processes of reuse, recycle, and reduce as well as new information in the development of knowledge and technology of new concrete materials.
2. Literature review

Conventional concrete as a composite material consisted of a mixture of portland cement or other hydraulic cements, fine aggregate, coarse aggregate and water, with or without any other materials [1], while concrete mixture composition consist of 7%-15% of cement, 14%-18% of water, 2%-8% of air, and 60%-80% aggregate [2]. Whereas, lightweight concrete is concrete with fine aggregate and weight less than 1880 kg/m³ [1].

Several studies have been previously conducted regarding the use of Styrofoam either as a mixture of concrete or as mortar functioning as a substitute or combination of brace in which the Styrofoam concrete with 10% of fly ash as replacement has better strength for 28 days compared to the other FPA replacement. Styrofoam concrete using 10 mm square aggregate has more compressive strength for 28 days compared to that using 20 mm square aggregate [3]. Some of the advantages of concrete consisting of Styrofoam are low cost, low weight so that it reduce the possibility of earthquake weight, and utilizing the Styrofoam waste itself [4]. Besides, adding Styrofoam to concrete is also able to reduce the specific gravity as much as 3.18% in average in every 10% of Styrofoam added [5].

In its generic terminology, Styrofoam is known as extruded polystyrene foam which is widely used nowadays. Some of other terminologies of Styrofoam are vinylbenzene, ethynyl benzene, cinnamene, and phenyl ethylene. Meanwhile, “Styrofoam” is a brand owned by Dow Chemical. The physical characters [6] of it are thermoplastic, light, shock-absorbing, isolating, hygroscopic [7], and easy to react with alkane and methane.

In the meantime, styrogravel is a developed product of Styrofoam which has been through a chemical reaction with methane resulted in a new compound namely jelly/ styrogel which is able to function as glue. This means that it can also react with cement as glue between surface and waterproof materials. With natural cooling system, styrogel can be formed into gravel according to the needs (sometimes they can be round, flat, or oval). They can also be adjusted to the contour of the surface (soft or hard) [8]. Based on previous studies, [8] it has been proven that styrogravels are solid to load pressure, not broken as how gravel is; it is just physically transforming, solid to the impact of hitting load, and solid to abrasion in aggressive situation since it is made of polystyrene which is difficult to decomposed and able to float. However, styrogravel is not endured to heat.

3. Method

To make the formula of styrogravel concrete, the composition of concrete mixture is necessary as reference by using a doe method which employs the results of concrete maker materials according to the existing standards based on the cement water factor as big as 0.5. The results of the composition are: 1 grit: 1.5 cement: 2.5 gravel and 0.19 lt of water. By maintaining the value of slump at 100 ± 20 mm and based on the composition, there is mixture of gravel as a variable with ratio of 05 grabel and 0.5 styrogravel also mixture with the whole styrogravel in it. The mixture process is run by machine to make sure that it is going well so that slump test can proceed after [9]. Printing of the tested material is done using a cylindrical printing device with diameter of 150 mm x 300 mm with checking preceding every one-third pouring of the materials [9]. The next process is letting the materials untouched for 24 hours to be further maintained by soaking system for 28 days [9]. To test the concrete performance, a hydraulic machine with maximum load of 200 ton is used [9].

4. Results and analysis

The results of concrete physical test are shown in Table 1.
Table 1. Results of tested materials

| Characteristics                        | Styrogravel Concrete | Conventional Concrete |
|----------------------------------------|----------------------|-----------------------|
| Specific Gravity (kg/m³)               | 1349.1               | 2534.6                |
| Weight Ratio/ Compressive Strength     | 0.00049              | 0.00045               |
| Tensile strength/ Compressive Strength Ratio | 0.13                | 0.06                  |
| Endurance to Maximum Load              | Tegar                | Getas                 |

In terms of weight, it is proven that styrogravel concrete has lower specific gravity than conventional concrete; thus, it is categorized as lightweight concrete [1]. Regardless the weight, it is shown that styrogravel concrete has more compressive strength ratio than conventional concrete. Styrogravel also shows better tensile strength ratio towards compressive strength when compared to conventional concrete.

The results of concrete mechanical test based on each strength and endurance of the mixture are described in Figure 1.

![Concrete Performance](image)

**Figure 1.** Comparison of the impact of load towards the concrete decrease.

Figure 1 shows that conventional concrete is better in carrying load in comparison with styrogravel concrete. Conventional concrete can carry as much as 24842.13 kg of load while styrogravel concrete can only carry as much as 15730.6 kg of load. This means that the weight of concrete represents its strength. However, if we do not consider the weight of the concrete, the ratio of styrogravel concrete is better than that of conventional concrete, meaning that styrogravel actually has better strength. In addition, Figure 1 also shows that styrogravel concrete has better performance in loading endurance. Styrogravel concrete is proven to be able to hold on in the high displacement when carrying maximum load. On the other hand, conventional concrete is already destroyed at the same time in the same condition.

5. Conclusions

The results of the analysis proves that styrogravel concrete has more advantages in comparison with conventional concrete. Some of them include its light weight, better endurance, compressive strength ratio towards more tensile strength, better ductility, not brittle, not easily broken in the high displacement, and made of waste. This indicates that styrogravel concrete has a lot of potentials to
replace conventional concrete is as construction material in the future. The natural characteristics of styrogravel concrete can also reduce the load of earthquake.

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