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UTILIZATION OF USED TIRES AND LDPE (LOW-DENSITY POLYETHYLENE) PLASTIC WASTE AS BASIC MATERIALS FOR CONCRETE BRICK

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Abstract

Tires and LDPE plastic wastes are wastes that are non-biodegradable and require further processing to decompose. If it is not processed, it will pollute the environment and disrupt the life of various organisms. Tires and LDPE plastic waste can, however, be used as a mixture for making concrete bricks that contribute best in building infrastructure development by applying the principle of recycling. The addition of a mixture of used tire waste and LDPE plastic waste is useful for improving the physical properties and pavement content of concrete bricks and preventing the depletion of natural resources, achieving an Eco-Friendly program and making the cost of concrete bricks relatively cheaper. Concrete bricks are made with a mixture of used tire waste and LDPE plastic waste with 6 samples of different compositions. The quality of concrete brick is seen from three aspects, namely density, porosity and water absorption. The best quality of concrete bricks was obtained in sample 6 with a composition of 750 grams of used tire powder, 750 grams of LDPE plastic waste, 500 grams of coarse aggregate, 200 grams of cement and 750 ml of oil to obtain a density of 1129.252/1280, 864 kg/m³, 0.5% porosity, 0.434 % water absorption. The results showed that the addition of a mixture of used tire waste and LDPE plastic waste resulted in better quality concrete bricks achieved by increasing the density of concrete bricks and reducing the porosity and water absorption values produced.

Keywords: *concrete brick, waste tires, LDPE plastic waste, density, porosity, water absorption.*

Introduction

Currently, infrastructure development is in the form of buildings such as housing, office buildings, shopping centers, hospitals, and others. In Indonesia, it is still not evenly distributed and only two main types of concrete bricks are used to build infrastructure, namely red brick or clay and hebel bricks. With the aim of preventing the depletion of natural resources used to make red bricks and hebel bricks and achieving an Eco-Friendly or Environmentally Friendly program, therefore the manufacture of concrete bricks from a mixture of waste tires and LDPE plastic is the best contribution in building infrastructure development in Indonesia by the same physical properties as red brick and hebel brick by applying the principle of recycling.

On the other hand, one of the causes of environmental problems that occur in Indonesia is the presence of waste scattered around our environment. In general, waste is building material or leftover material that is no longer used as a result of human activities either at the household, industrial, or mining scale. The presence of waste can have a negative impact on the environment and on human health, so it is necessary to carry out proper handling of waste [1].

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The author wants to focus on the waste of used tires because based on records by the Ministry of Industry of the Republic of Indonesia (Kemenperin) that the tire industry is one of the leaders in the rubber and rubber goods sector by absorbing more than 250 thousand tons of natural rubber per year and growing steadily over the last two decades. Not only that, the total production of two-wheeled vehicles throughout 2019 reached 7.2 million units and is estimated to continue to increase, so that this increase in demand will also have an impact on increasing the demand for domestic tires. On the other hand, the increase in the use of tires in the country will have an impact on the number of used tires produced from this mode of transportation. These used tires have the potential to pollute the surrounding environment if they are not processed because used tires are made from rubber, which is a type of synthetic polymer polystyrene (polystyrene) which is not biodegradable and requires further processing to decompose it [2].

In addition to used tire waste, the author also focuses on plastic waste because plastic waste is the most common waste found in Indonesia and it takes the earth at least tens of years to hundreds of years to completely decompose plastic. If in the near future plastic waste continues to accumulate while it takes a long time to decompose plastic waste, it can pollute the environment and disrupt the lives of organisms around it. Regarding plastic waste, plastic itself is made from oil and natural gas as the basic ingredients. Plastics are divided into seven types, namely Polyethylene Terephthalate (PET, PETE, or polyester), High-Density Polyethylene (HDPE), Polyvinyl Chloride (PVC), Low-Density Polyethylene (LDPE), Polypropylene (PP), and Polystyrene (PS) [3]. Regarding the types of plastic waste described earlier, Low-Density Polyethylene (LDPE) is the most widely used type of plastic worldwide. This is because LDPE type plastic has a simple polymer chemical structure, making it easy to produce as the main ingredient for making single-use plastic bags.

Plastic waste that was previously only as an item that pollutes the environment, can actually be used into various kinds of lightweight construction materials that are very beneficial for human life. Besides being able to be utilized from a technical point of view, processed materials from plastic waste have a high economic value. One example is the use of single-use plastic waste as a mixture for making concrete bricks. Making concrete bricks which are generally made of cement and sand has an expensive price, while making concrete bricks made from LDPE plastic waste is more economical because it is made from single-use plastic waste. Single-use plastic waste whose base material is LDPE (Low-Density Polyethylene) is able to improve the performance of concrete bricks in receiving repeated loads due to tire repetition and improve the physical characteristics of concrete bricks. Not only that, LDPE from single-use plastic waste can increase the pavement content of concrete bricks so as to strengthen the building's foundation [4].

The paper presents the the effect of using a mixture of waste tires and LDPE-type plastic as the basic material for making concrete bricks on improving the physical properties of concrete bricks.

Experimental

Materials

The materials used in this research include waste tires obtained from waste tire fields located in the District of Bojong Nangka, Bogor Regency, West Java. Used oil waste is obtained from various workshops in the Karangsatria area, Bekasi Regency, West Java. LDPE plastic waste was obtained from single-use plastic bags at the researcher's house, Bekasi City and the Warehouse of SMA Labschool Cibubur. The cement is Portland Cement (PC), fine aggregate in the form of sand, and coarse aggregate in the form of gravel. Then, glycerin is supplied from the Chemistry Laboratory of SMA Labschool Cibubur.

Table 1. Details of the composition of each sample of concrete brick

Sample	Used Tires Waste (powder) (g)	LDPE Plastic Waste (g)	Fine Aggregate (g)	Coarse Aggregate (g)	Cement (g)	Used Oil Waste (cm^{3})
S-1	700	100	1200	-	200	750
S-2	700	100	-	1200	200	750
S-3	1200	100	700	-	200	750
S-4	1200	100	-	700	200	750
S-5	750	750	500	-	200	750
S-6	750	750	-	500	200	750

Methods

The method used in this study is a quantitative experimental method with data collection techniques using experiments and testing of samples and using the literacy method through journal articles, thesis, theses, dissertations, or scientific works on related material.

Preparation of Used Tires and Used Tire Powder

As many as 6 used tires are prepared from used tire waste. Then the cutting process is carried out so that 104g of used tire powder is prepared afterwards to facilitate the process of making concrete brick samples.

Making Concrete Brick Samples

Cut up single-use plastic bags which are LDPE type plastic waste and put the pieces of plastic into the pot. After that, overwrite it with used tire powder so that the plastic pieces melt faster, then let it rest for about 15 minutes. Then add the oil so that the LDPE plastic and the used tire powder melts quickly and stir for 10 minutes. After stirring, add fine aggregate (sand) or coarse aggregate (gravel) then leave for about 15 minutes until the mixture of the concrete brick sample is soft. Finally, add cement so that the concrete brick sample becomes harder, stir for 5 minutes, and pour the mixture into the 18cm x 9cm x 5cm aluminum block mold that has been greased with glycerin. Details of the composition of used tire powder, LDPE plastic waste, fine aggregate (sand), coarse aggregate (gravel), cement, and oil in each sample are shown in Table 1. After that, wait for the concrete brick sample dough for 3 days, then remove the six samples from the mold. The six samples of concrete brick that had been separated from the mold were allowed to stand for 24 hours so that the six samples were suitable for testing.

Testing Concrete Brick Samples

The test components that will be carried out by each sample of concrete brick, namely physical properties test consisting of density test, porosity test, and water absorption test.

Results and Discussion

The manufacture of concrete bricks made from waste tires and LDPE (Low-Density Polyethylene) type plastic aims to determine the characteristics of the physical properties. It is expected that the concrete brick has the optimum density, porosity, and water absorption values compared to previous studies. From the results of tests that have been carried out on samples of concrete bricks made from waste tires and LDPE type plastic, the data obtained from the analysis results.

Density

Density testing is carried out by measuring the mass of each unit volume. The higher the density of an object, the greater the mass of each volume. The results of density measurements are obtained as shown in Table 2.

Table 2. Density test

Sample	Sample Mass (g)	Sample Volume (g)	Density (g/cm^3)
S-1	875	810	1.080
S-2	921	810	1.137
S-3	736	810	0.909
S-4	814	810	1.005
S-5	911	810	1.125
S-6	1037,5	810	1.281 [5]

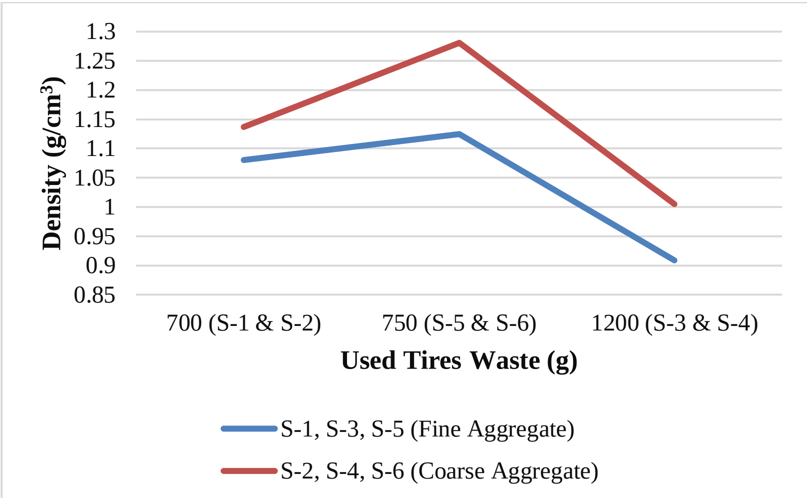

Fig. 1. The relation between density and variation in the composition of used tire waste

Figure 1 shows that there is a decrease in the density value in each addition of used tire waste from 1.125g/cm^3 to 0.909g/cm^3 in samples using fine aggregate (sample codes S-1, S-3, and S-5) and from 1.281 g/cm^3 to 1.005g/cm^3 in samples using coarse aggregate (samples code S-2, S-4, and S-6). Based on the theory, the effect of adding used tire waste to density is that the more waste tires used, the smaller the density of concrete bricks produced [6]. This happens because along with the increase in the amount of filler material, the porosity and empty space in the composite also increases. Porosity will make the composite lighter because the total volume of the composite becomes larger but it is not accompanied by an increase in mass where in this case what fills the porosity space is air with a very low density value [7]. However, in this study there were differences observed in the fifth and sixth samples, namely using 750g of used tire waste has a greater density than the use of 700g of used tire waste in the first and second samples. This is because there are differences in the composition of other variables, namely LDPE plastic waste.

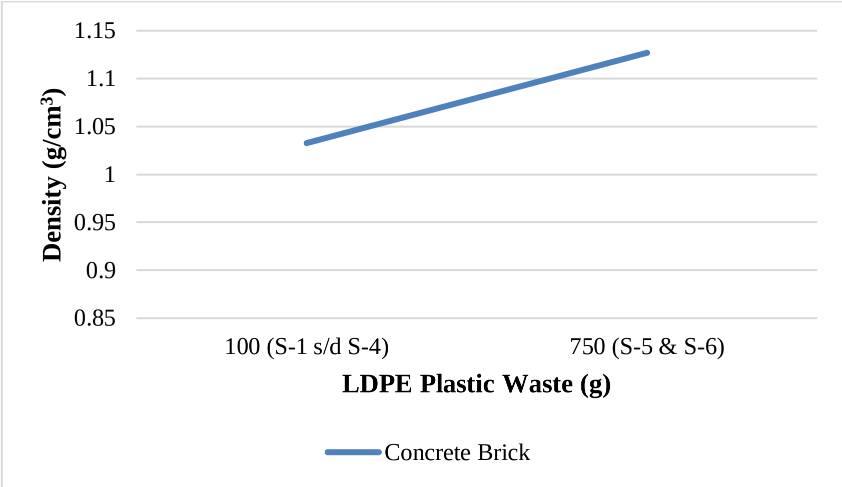

Fig. 2. The relation between density and variation in the composition of LDPE plastic waste

Figure 2 shows that there is an increase in the density value for each addition of LDPE plastic waste from 1.033g/cm^3 (the average density of the first to fourth samples because it uses the same composition of LDPE plastic waste, which is 100g) to 1.203g/cm^3 (average). the density of the fifth and sixth samples because they use the same composition of LDPE plastic waste, which is 750g). Therefore, the addition of LDPE plastic waste causes an increase in the density of the sample. This is because more and more LDPE plastic compositions are used so that the bonds between plastic molecules in the composition of the concrete brick sample become stronger and result in a larger sample density [8].

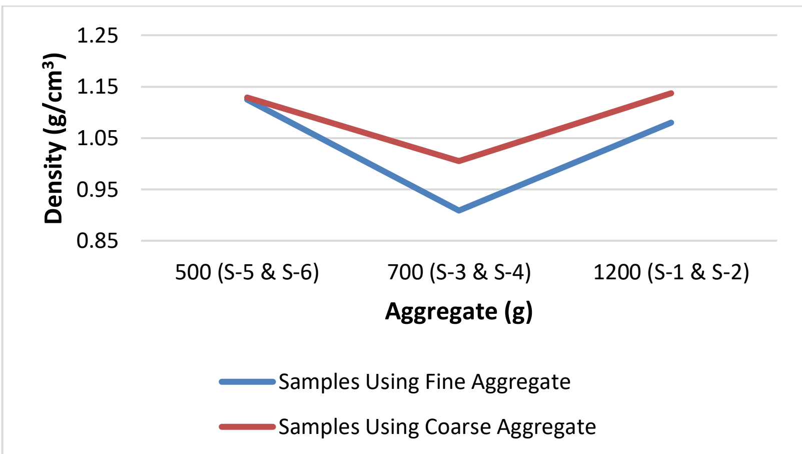

Fig. 3. The relation between density and variation in the composition of aggregate

Figure 3 shows that the sample using fine aggregate (S-1, S-3, and S-5) has a lower average density (that is, 1.038g/cm^3) than the sample using coarse aggregate (S-2, S-4, and S-6) that is equal to 1.141g/cm^3. This is because the use of fine aggregate in the concrete brick causes the voids in the concrete brick to become very large so that the density of the concrete brick becomes smaller [9]. The graph is not linear because there is an influence from the composition of LDPE plastic waste and different used tires.

For samples using fine aggregate, namely sand (S-1, S-3, and S-5), the optimum condition was obtained in the 5th sample with a density of 1.125g/cm^3 because based on concrete brick standards, the density of concrete bricks which can be used in its application as a building construction material is 1.4g/cm^3. For samples using coarse aggregate, namely gravel (S-2, S-4, and S-6), the optimum condition was obtained in the 6th sample with a density of 1.281g/cm^3 because it is close to the standard density of concrete brick, which is 1.8g/cm3 in its application as a building construction material [10].

Porosity

Porosity can be defined as the ratio between the volume of pores to the total volume of the concrete brick. From the porosity test, the data results are obtained as shown in Table 3.

Table 3. Porosity test

Sample	Total Sample Volume (cm^3)	Sample Dry Mass (g)	Sample Wet Mass (g)	Porosity (%)
S-1	810	875	884	1.1
S-2	810	921	932	1.358
S-3	810	736	747	1.358
S-4	810	814	822	0.988
S-5	810	911	918	0.864
S-6	810	1037.5	1042	0.5

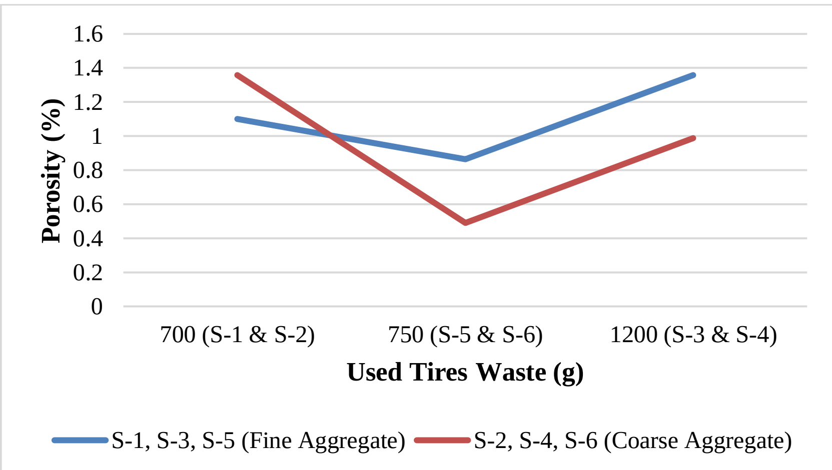

Fig. 4. The relation between porosity and variations in the composition of used tire waste

Figure 4 shows that the relationship between porosity and composition variation of used tire waste is not linear due to the influence of different compositions of components other than waste tires. The porosity in the first sample is lower than the second sample due to the uneven distribution of components.

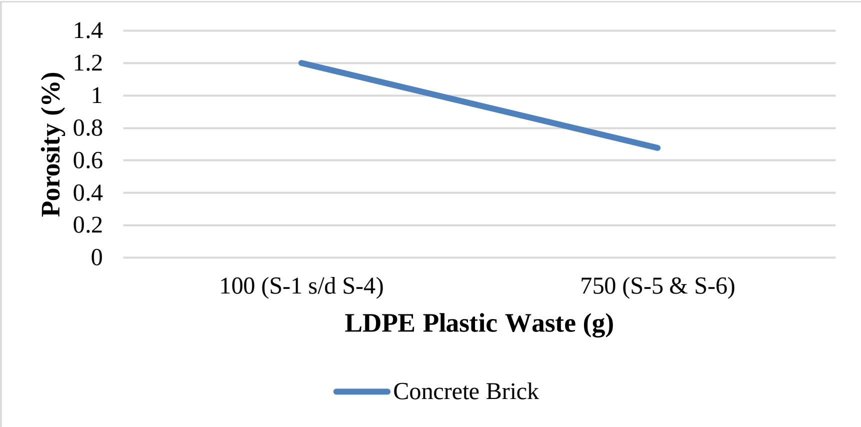

Fig. 5. The relation between porosity and variations in the composition of LDPE plastic waste

Figure 5 shows that there was a very drastic decrease in the composition of 100g and 750g LDPE plastic waste from 1.201% (average porosity of the first to fourth samples) to 0.677% (average porosity of the fifth to sixth samples). This is because more and more LDPE plastic compositions are used so that the bonds between plastic molecules in the composition of the concrete brick sample become stronger and the resulting pores are less so that the more LDPE content in the sample, the lower the porosity. The higher the composition of LDPE, the density will increase as shown in Figure 2. The higher the particle density, the higher the bond between the particles so that the porosity in the sample will be smaller [11]. It can be concluded that the optimum conditions were obtained in the fifth sample and sixth sample because it used the largest LDPE plastic waste composition of 750g so that both samples had the best density.

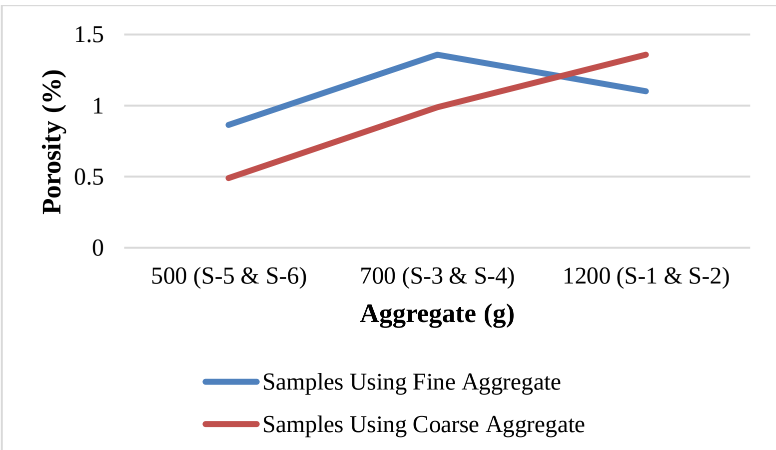

Fig. 6. The relation between porosity and variations in the composition of aggregate

Figure 6 shows that there is an increase in the value of porosity from 0.49% to 1.358% in the sample using coarse aggregate (S-2, S-4, and S-6) and from 0.864% to 1.358% in the sample using fine aggregate (S-1, S-3, and S-5) and the average porosity of the sample using coarse aggregate (that is, 0.945%) is lower than that of the sample using fine aggregate (that is, 1.107%). However, between the first sample using 1200g fine aggregate and the second sample using 1200g coarse aggregate, the porosity value of the first sample is lower than that of the second sample due to poor mixing so that the cement is not evenly distributed. This is because the more the use of the amount of aggregate plus the type of aggregate which is fine aggregate, it causes the concrete brick to become more hollow so that the porosity of the concrete brick becomes greater. It can be concluded that the optimum condition was obtained in the sixth sample because it used coarse aggregate and had the smallest aggregate composition of 500g so that the sixth sample had the best density.

Water Absorbency

The water absorption test aims to determine the amount of air absorbed by the sample immersed by immersion for two hours at room temperature. The results of the water absorption test are shown in Table 4.

Table 4. Water Absorbency test

Sample	Sample Dry Mass (g)	Sample Wet Mass (g)	Water Absorbency (%)
S-1	875	884	1,028
S-2	921	932	1,194
S-3	736	747	1,494
S-4	814	822	0,983
S-5	911	918	0,768
S-6	1037,5	1042	0,434

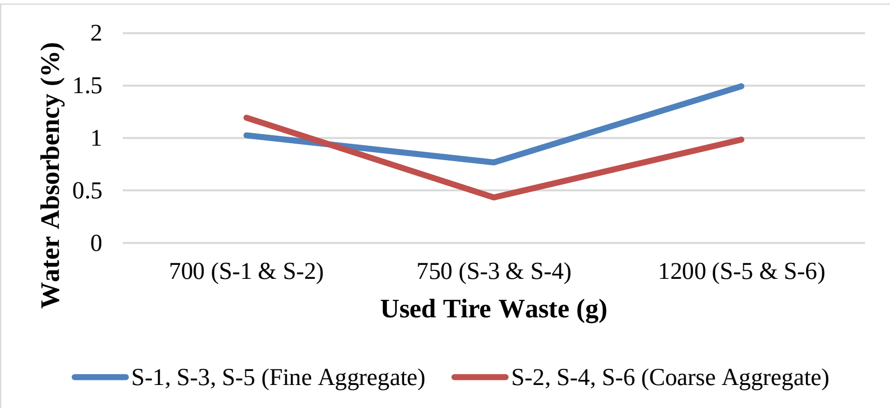

Fig. 7. The relation between water absorbency and variations in the composition of used tire waste

Figure 7 shows that the relationship between water absorption and variations in the composition of used tire waste is not linear due to the influence of the composition of LDPE plastic waste, fine aggregate, and coarse aggregate.

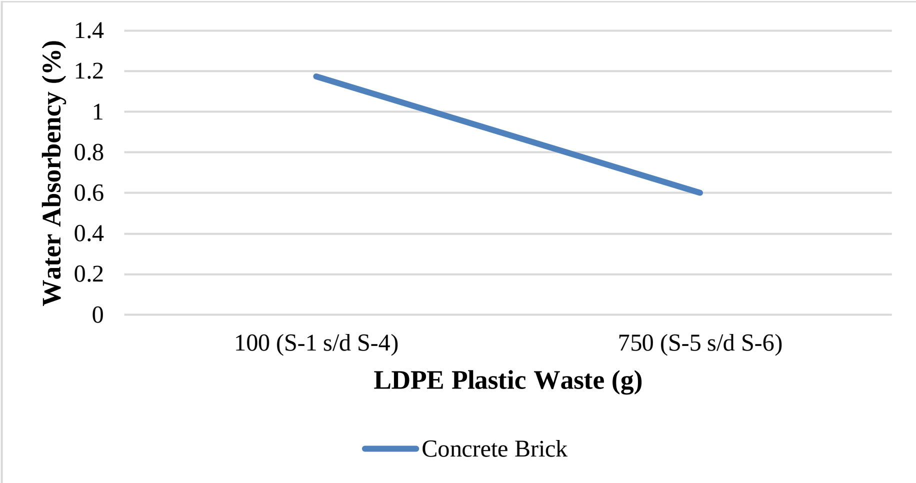

Fig. 8. The relation between water absorbency and variations in the composition of LDPE plastic waste

Figure 8 can be seen that the water absorption decreased from 1.175% (average water absorption of the first to fourth samples) to 0.601% (average of water absorption of the fifth and sixth samples). The water absorption decreased as the amount of LDPE used in the composition of the concrete brick sample increased. This is due to the immersion process, water is difficult to fill the empty spaces in the concrete brick and results in increased contact or cohesiveness between LDPE and other compositions (fillers) which if mixed both will be hydrophobic so that water or water vapor will be increasingly difficult to enter. into the concrete brick. It can be concluded that the optimum conditions were obtained in the fifth and sixth samples because they used the largest LDPE plastic waste composition of 750g so that both samples were more impermeable to water.

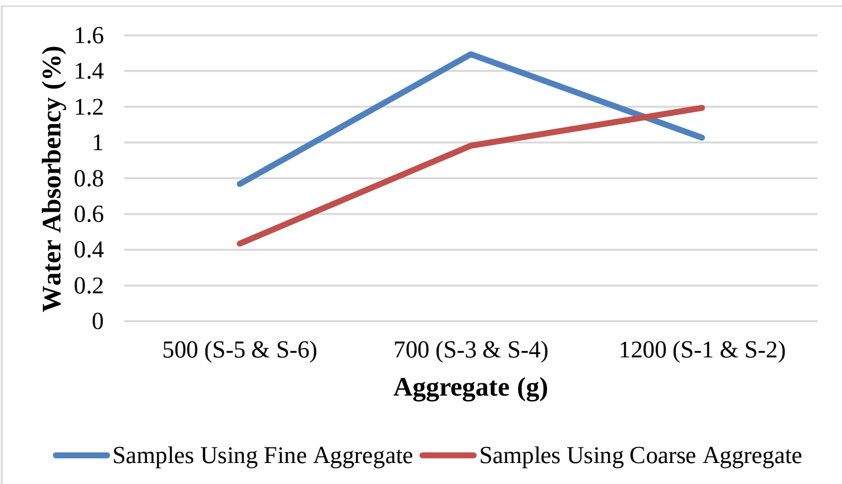

Fig. 9. The relation between water absorbency and variations in the composition of aggregate

Figure 9 shows that there is an increase in the value of water absorption from 0.434% to 1.194% in samples using coarse aggregate (S-2, S-4, and S-6) and from 0.768% to 1.494% in samples using fine aggregate (S-1, S-3, and S-5) and the average water absorption of samples using coarse aggregate (that is, 0.87%) is lower than that of samples using fine aggregates (which is 1.096%). However, between the first sample using 1200g fine aggregate and the second sample using 1200g coarse aggregate, the water absorption value of the first sample is lower than that of the second sample due to poor mixing so that the cement is not evenly distributed. This is because the more the use of the amount of aggregate plus the type of aggregate which is fine aggregate, it causes the concrete brick to become more hollow so that the water absorption capacity of the concrete brick becomes greater. It can be concluded that the optimum condition was obtained in the sixth sample because it used coarse aggregate and had the smallest aggregate composition of 500g so that the sixth sample was more impermeable to water.

Conclusions

Based on the data that has been obtained by the author through quantitative experimental methods, it can be proven that by mixing the two wastes, it can produce concrete bricks with better quality than using just one waste. The optimum condition was obtained in the sixth sample (S-6) with a density value of 1.281g/cm3, porosity of 0.5%, and water absorption of 0.434%.

In general, the use of fine aggregate and coarse aggregate in concrete bricks also affects the density, porosity, and water absorption of the concrete bricks. Based on the type of aggregate used, the optimum conditions were obtained in samples using coarse aggregate (S-2, S-4, and S-6) because the use of coarse aggregate in concrete bricks will reduce the voids in the concrete bricks so that the density of the concrete bricks becomes higher. large and the porosity and water absorption are smaller than the samples using fine aggregate (S-1, S-3, and S-5). Based on the amount of aggregate used, the more the amount of aggregate used, the more hollow the concrete brick will be, so that the porosity and water absorption of the concrete brick will be greater.

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