Mechanical Properties of Geopolymer Grout with Bagasse Ash and Resin Catalist

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Mechanical Properties of Geopolymer Grout with Bagasse Ash and Resin Catalyst

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Abstract. Concrete can crack which causes a decrease of performance in the structure of the building. It requires an improvement in the damage in the concrete so that the strength returns to normal. This research was conducted to find a mixture of materials with the appropriate composition in order to restore the strength of the damaged concrete by using a new mixture modification. The material used in this study is using bagasse ash derived from sugar mill waste and chemical resin catalyst as a substitute for water and binder. The mixture was made using 5 variations in the volume ratio of catalyst resin and bagasse ash, namely 1: 0.4, 1: 0.53, 1: 0.67, 1: 0.8, and 1: 1. This research tested the mechanical properties of the specimens that have been made from the mix proportion. The result of the research that has been shown is that the addition of sugarcane ash in a mixture with resin catalyst levels continues to increase in the compressive strength. The increasing age of the concrete also increases the value of compressive strength on the specimens. The highest compressive strength is obtained by mixing material with a ratio of 1: 1, it was 96.18 MPa. The grouting material that has been made is also less effective when injected into damaged parts of the concrete because it has a thick texture which makes the material difficult to inject so that it requires greater pressure than the grout material from a mixture of cement and water

Keywords: Grouting, Mechanical Properties, Bagasse Ash, Resin Catalyst.

1 Introduction

Concrete structure is one important component in the sustainability of infrastructure in the world. All countries in the world use concrete as one of the main materials in the construction of infrastructure such as buildings, bridges and roads [1]. Concrete constituent components are generally composed of aggregates, cement and water, which produce a pretty good compressive strength besides easy to produce [1, 2]. Durability in concrete is influenced by various factors. If the value of elastic strain exceeds tensile strain capacity, then cracks will begin to occur in the concrete [3]. This cracking process can be caused by shrinkage and creeps and other factors. If the crack is left continuously, it will be probable that the crack width will increase. As time

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goes by, the crack will reduce the value of the structure durability. In reinforced concrete structures, this case will cause the steel reinforcement in the concrete to corrode which is certainly very bad for the structure. Through these problems, of course, cracks must be repaired, one of the methods used to repair cracks is by grouting.

In general, the constituent material for grouting consists of grout cement and water. Grouting or retrofitting process is by inserting a thin enough cement paste into the crack in the concrete. The advantage of this method is that it is very fast for the repair process. The strength of grouting material usually has a fairly high initial compressive strength. The use of grouting is very suitable for buildings which are cracked due to an earthquake or for structures which have cracked due to shrinkage and creeps. Application of grouting has also been made in real construction, both conventional grouting and using special methods grouting. Some research results show that grouting technology has been applied to shield tunnel construction [4-6], offshore wind turbine [7, 8], Drainage pipe [9, 10], repairs to beams, columns, plates and beam-column connections [11-15], and is used to connect connections to prestressed concrete [16, 17].

Besides using conventional methods, the concept of grouting continues to develop. The development of the concept of composing grouting material is also inseparable from innovation with the use of eco-materials so produ g grouting, which is more environmentally friendly. This research will use the innovation of the use of bagasse ash as a constituent of grouting mixed with catalyst resin as a binding agent to produce grout geopolymers. In previous studies, many have developed concepts like this by using other waste materials such as fly ash [18-20] and bottom ash [21]. In addition, the use of resins as grouting and mortar materials has also been widely conducted, including using polyester resin [22, 23], polymeric resin [24], and epoxy resin [25

The use of Bagasse Ash as a construction material is one of the innovations which quite rapidly develop. In the previous research phase, innovation has been carried out with the use of bagasse ash as construction material, including the use of bagasse ash for making mortars [26-28]. This research will utilise bagasse ash and catalyst resin as basic material for making grouting. The test consists of a fresh properties test and a hardened properties test, in the fresh properties condition, the examination of the spread value or flowability, a thickness value and a time setting will be performed. Meanwhile, in the hardened conditions, the examination of unit weight and compressive strength will be performed at the age of 3, 7, 14 and 38 days. The mixture variations used in this study were 60, 80, 100, 120 and 150 ml bagasse ash using the same volume of resin in each mixture. Through this research, it is expected to utilise bagasse ash waste which has not been used optimally in Indonesia to become material of economic value.

2 Experimental Program

This study used an experimental method based on laboratory testing. In this section, the material and mix proportion, and the method of testing on each test object will be explained. The material used in this study consisted of bagasse ash and resin catalyst. The test consisted of flowability, viscosity value, setting time, unit weight and compressive strength. Bagasse ash used in this study came from sugar processing waste in Bantul, Yogyakarta, Indonesia.

2.1 Material and Mix Proportion

This study used two main materials, namely bagasse ash and resin catalyst. Resins are chemicals with a thick texture and can harden if dropped with a catalyst. The more catalysts pped, the faster the mixture will harden. Bagasse is a material used as a substitute for cement obtained from the burning of sugarcane bagasse from sugar production waste. Bagasse ash has

been widely applied in previous studies that have been explained in the introduction. This study used five variations of bagasse ash using the volume control. Table 1 shows the variation of the mixture used in this study.

Table 1 Comparison of mixed compositions

ID	Comparison	a volume unit (ml)	
		Resin	Bagasse Ash
G1	1 : 0,4	150	60
G2	1 : 0,53	150	80
G3	1 : 0,67	150	100
G4	1 : 0,8	150	120
G5	1 : 1	150	150

2.2 Method of Testing

In this study, testing fresh properties was in the form of flowability, thickness value and time setting. As for the hardened properties test, unit weight and compressive strength tests will be performed. Compressive strength testing was carried out at day 3, 7, 14 and 28. Flowability testing was conducted shortly after finishing the mixing each material. This flowability test aims to determine the ability of the material to flow to meet parts that are difficult to compact.

3 Result and Discussion

3.1 Fresh Properties

Flowability test was carried out for each variation, as shown in Figure 1. The results show that if the amount of bagasse ash increases, the flowability value of the grouting material will be decreased. Bagasse ash mixture of 60 ml produced a flowability value of 342.5%; the value continues to decrease as the amount of bagasse ash increased. In a 1: 1 mixture, bagasse ash of 150 ml for each specimen produces a flowability value of 280%. Flowability value will decrease as bagasse ash increases. This is because bagasse ash which is dry enough to absorb the resin during the stirring process makes the mixture more difficult to spread. It is important to pay attention to the standards for the minimum requirements for flowability that are allowed if this material is used for grouting in construction projects.

The thickness test was also done by measuring the time of fresh grouting flowing through the funnel that has been determined according to the standard. Figure 2 is the result of thickness testing on concrete. The greater the value indicates that the grouting material is thicker and more difficult to flow or increasingly requires great pressure to be injected into the concrete if the grouting is used to repair the concrete. The test results show that the more the bagasse ash value increases the thickness value will increase, and the more time it takes to flow. When using 60 ml bagasse ash, fresh grouting can flow with 7.42 seconds, while using 1: 1 proportion, the fresh grouting flow time will be 32.07 seconds. The faster the flow time, the better it is for fresh grouting, with increasing bagasse ash, a load of liquid resin will increase to bring the solid mass to the empty pores.

The last fresh properties test is the setting time test, which aims to find out the final time of grouting material becomes hard. The results in Figure 3 show that the more the amount of the bagasse ash, the faster the setting time will be resulted. In a 60 ml bagasse ash mixture, it takes 552 minutes to harden. Meanwhile, when using 150 ml bagasse ash, it takes 300 minutes only

to harden. This phenomenon occurred because the more bagasse ash is used, the more resin is absorbed then, it will harden faster. The setting time has a crucial role in the hydration process of grouting material. Sooner or later, the hardening process becomes an important consideration.

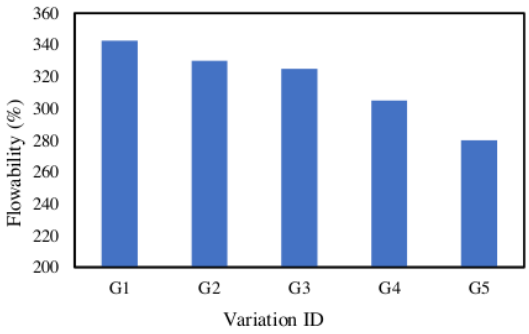


Fig 1. Flowability result for each variation

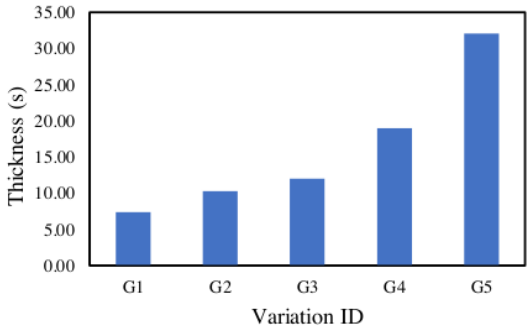


Fig 2. Thickness result for each variation

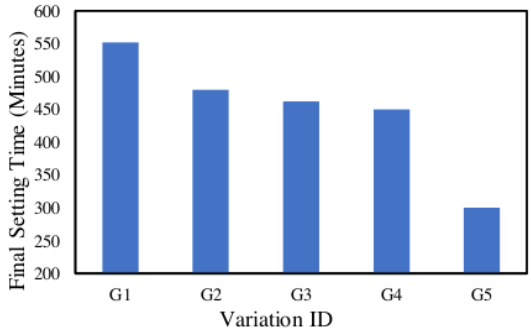


Fig 3. Final setting time for each variation

3.2 Hardened Properties

The unit weight test is also carried out to determine the weight produced. In the 60 ml bagasse ash mixture, it provides 1.4 gr/cm3. At the same time, in the other combinations, it was obtained a unit size ranging from 1 -1.2 gr/cm3. Fig. 4 is the result of unit weight test.

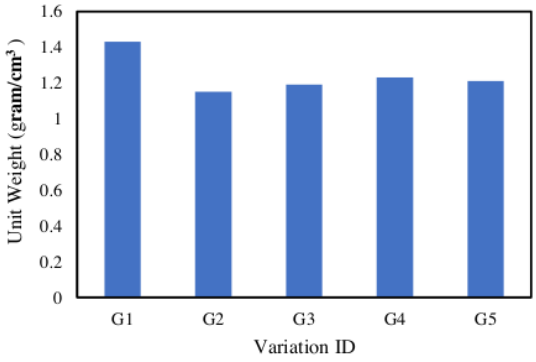


Fig 4. Unit weight for each variation

The compressive strength test was carried out at 3, 7 14 and 27 days. Figure 5 is the result of the relationship between compressive strength and curing time. In this test, the curing was carried out by using water curing for 28 days. The compressive strength of the specimen with a size of 5 x 5 x 5 cm in each result for each variation consists of 3 specimens. In Figure 5, it can be seen that the more the amount of bagasse ash, the higher the value of the compressive strength. However, for the age of 28 days, the compressive strength produced does not have a significant difference among the variations.

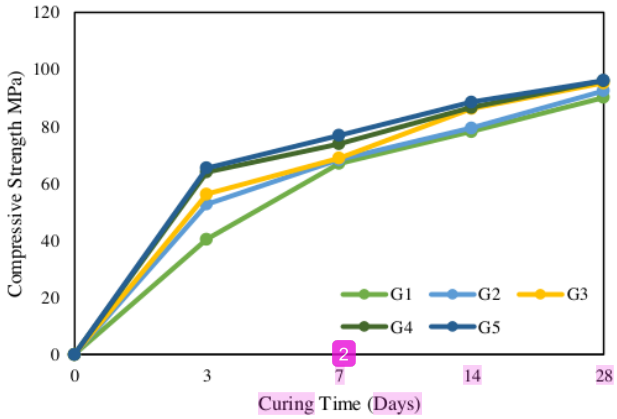
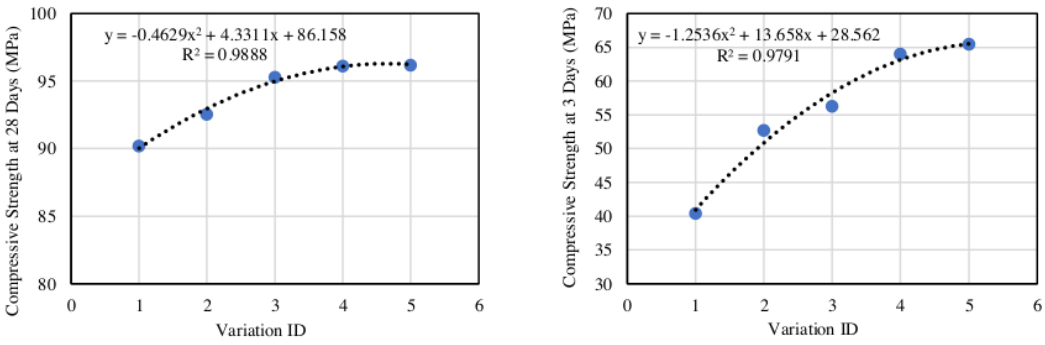


Fig 5. Compressive strength vs curing time

Figure 6 shows the relationship between each variation on the compressive strength produced at 28 days and three days. Figure 6(a) shows the increasing amount of bagasse ash used; the compressive strength produced will increase. In a mixture of 60 ml bagasse ash, the compressive strength produced is 90 MPa at 28 days. Meanwhile, a 150ml bagasse ash mixture provides a compressive strength of 96.18 Mpa. This result indicates an increase of 6.87%. Moreover, at the age of 3 days, a mixture of 60 ml bagasse ash has a compressive strength of 40.38 Mpa while a 150 ml mixture produces a compressive strength of 65.43 Mpa. This result shows a significant increase, which is equal to 62.05%.

The high early strength concrete indicates that the increasing content of bagasse ash in the mixture will produce a better high early strength concrete even though at the age of 28 days, the compressive strength has an insignificant difference. However, the level of flowability and workability need to be focused because if there is excessive content of bagasse ash, then the level of dilution from grouting will decrease. As a consequence, the material will be difficult to be processed.

Also, several focus things are the level of refinement of bagasse ash, the finer the bagasse ash, the value of flowability in fresh grouting will increase because the level of dilution will be better. Thus, good compressive strength and fresh properties can be obtained. In this study, several tests were also carried out, including absorption and moisture content, but the excess of resin catalyst which did not absorb water caused the absorption results to be absent. It is better for further research to have the test of durability and absorption in a long time; then, the durability of this type of grouting can be known. The use of 150 ml bagasse ash is the maximum level that can be used. The higher the bagasse ash used, the less good the value of fresh properties.



(a) (b)

Fig 6. The relationship between compressive strength and amount of bagasse ash (a) 28 days (b) 3 days

4 Conclusion

Based on the results of the study, it can be concluded that the more bagasse ash is used, the value of flowability will decrease, and the level of viscosity will increase. This result shows that there are restrictions on the use of bagasse ash as grouting material. Although the compressive

strength results indicate that the more bagasse ash used will produce a higher compressive strength, specifically for the initial compressive strength of 3 days. However, the use of 150 ml content of bagasse ash is still very acceptable for grouting material.

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