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Influence Substitution of Tabas Stone Waste which Coated Polyester Resin to Concrete Compressive Strength

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ABSTRACT

The need for the use of concrete raw materials is increasing in line with the increase in the use of concrete in construction. The availability of concrete raw materials is dominated by the exploitation of natural resources, namely components of cement, sand and crushed stone or gravel. If the availability of this material is exploited in excess, it will have an impact on environmental damage. On the other hand, many stone crafts for decoration and building ornaments in Bali also utilize tabas stone which is also exploited from nature, where the processed rock leaves a lot of waste that is disposed of without any wise processing actions. Tabas stone waste management is expected to maximize the utilization of natural resources and also reduce environmental pollution caused by the disposal of tabas stone waste that is not managed properly. This research is expected to provide an alternative to maximize the use of tabas waste as a partial substitution of crushed stone or gravel as coarse aggregate in concrete mixtures. The porous structure of tabas stone and the high level of water absorption in the concrete mix can reduce the compressive strength of the concrete. Steps to reduce water absorption in tabas stone are carried out by maximally closing the pores using a polyester resin coating. The study was carried out by making normal concrete mixture objects according to SNI 03-2834-2000. The percentage of substitution of crushed stone with waste stone that is coated with polyester resin is 0%, 25%, 50%, 75%, 100% of the required weight of coarse aggregate. The compressive strength of the concrete will be tested at the age of 7 and 28 days using a cylindrical specimen measuring 150x300mm. Test results in the laboratory showed that the coating of tabas stone using polyester resin was able to reduce the level of water absorption from 9.96% to 3.24% or 67.5% compared to tabas stone that was not coated with polyester resin. The optimum compressive strength of coarse aggregate substitution using tabas was obtained at variations of 50% crushed stone 50% tabas stone at the age of 7 days and 28 days, respectively, reaching 15.06 MPa and 21.55 MPa.

Key word: tabas stone waste; coarse aggregate; water absorption; polyester resin; compressive strength of concrete.

INTRODUCTION

The need for the use of concrete raw materials is increasing in line with the increased use of concrete in construction. Concrete consists of coarse aggregate, fine aggregate, cement, water and additives (ACI committee 318, 2011). Concrete, which is the choice of building material, has advantages compared to other materials such as wood and iron. This is because, among other things, concrete has low maintenance costs, raw materials that are easy to get, are resistant to fire, and the compressive strength of concrete is relatively higher than other materials. However, concrete also has a weakness because it has a relatively large specific gravity, which is around 2200-2400 kg/m3 (SNI 03-2847, 2013).

With the advantages and disadvantages that concrete has, the use of concrete remains high so that the demand for raw materials for making concrete is increasing. These raw materials are obtained by natural exploitation which can damage the environment. For example, the process of making cement in its production requires enormous energy due to heating to a temperature of 1500°C (Batubara et al., 2015). The production of each ton of cement clinker including its fuel is almost equivalent to one ton of CO2 released into the atmosphere. In recent years, world cement production has been recorded at 4 billion tons per year, which means that around 4 billion tons of CO2 gas has been released into the atmosphere each year (Ellis et al., 2019). In addition, the exploitation of sand and stone materials will cut the vegetation on it, excessive use of groundwater will result in lowering of the soil surface above it, and so on.

Concrete technology is always being developed to minimize the impact of environmental damage caused in order to answer the challenge of high levels of concrete demand in construction. Before the discovery of technology that can replace all of these raw materials, the way that can be done now is to reduce the use of cement, use of natural sand and natural stone in concrete mixes without reducing quality, workability and durability.

Several alternatives to replace coarse aggregate have been carried out. One way is to use pumice as a coarse aggregate in a lightweight concrete mix (Desai, 2011; Karthika et al., 2020; Mukesh Dattaram Ghadge & Vaibhav Dhondiram Kamble, 2015; Saini et al., 2018; Sangeetha et al., 2020). The resulting strength is not equivalent to using ordinary gravel, but the resulting specific gravity is much lower (<1900 kg/m3). There is also research on the effect of adding paint to pumice coarse aggregate, testing the absorption of coarse aggregate between ordinary pumice, painted pumice and gravel as a control. The paint used is polymer paint (water proof paint) which is used in the market and is not subject to special testing. The results showed that the water absorption rate between ordinary pumice stone, painted pumice stone and gravel was 14%; 10.1%; 3.2%. This proves that there is the effect of paint coating the surface of the pumice aggregate which causes water absorption of the pumice aggregate to decrease (Kurniawan et al., 2016).

In addition to pumice, the use of tabas stone as an alternative to coarse aggregate has been extensively studied before. Bali is known as an area where the business of decorative arts and traditional building ornaments uses tabas stones. Behind this, improper management of tabas waste can threaten environmental pollution. Several studies using tabas stone as an aggregate in concrete mixtures have been carried out (Salain et al., 2019; Sunaryo, 2007). Apart from being a coarse and fine aggregate, many tabas wastes also use it as an additive or filler ((Intara et al., 2013; Triswandana et al., 2021). From the results of research that has been carried out, using tabas waste in the mixture concrete can increase the strength of concrete at a certain percentage (Salain et al., 2020; Triswandana et al., 2021), some can reduce the strength of concrete.

The porous structure of tabas stone and the high level of water absorption in the concrete mix can reduce the compressive strength of concrete. One of the innovations to overcome this problem in this research is to try adding polyester resin to cover the pores of the tabas stone before it is added to the concrete mix. This innovation is expected to reduce water absorption in tabas stone which can be used as a substitute for coarse aggregate in concrete mixtures so as to produce good quality and environmentally friendly concrete.

RESEARCH METHODS

Materials

Tabas stone is an igneous rock type of scoria basalt which is usually rough, massive, hard and slightly porous in texture (Figure 1). Basalt is a volcanic igneous rock, which occurs from the freezing of magma with an alkaline composition at or near the surface of the earth. Basalt is often used as a raw material in the polishing industry, building materials/building foundations (buildings, roads, bridges, etc.) and as an aggregate. Tabas stone can be considered as a potential alternative material to replace coarse aggregate in concrete mixes because of its shape and texture. The use of tabas stone as a coarse aggregate can achieve a strength of around 20 MPa (Salain et al., 2019).

It is estimated that the compressive strength of the concrete can still be increased if the absorption value of the tabas stone aggregate can be reduced. Efforts to reduce the absorption of porous tabas aggregate will be carried out by giving treatment in the form of coating with Polyester Resin, where by partially closing the pores of the tabas stone it is hoped that the absorption can be reduced. Polyester resins are the most widely used resins in various applications that use thermoset resins, either separately or in the form of composite materials. The properties of polyester resins are specially designed for surface finishes which remain sticky in open air to further strengthen the bond.

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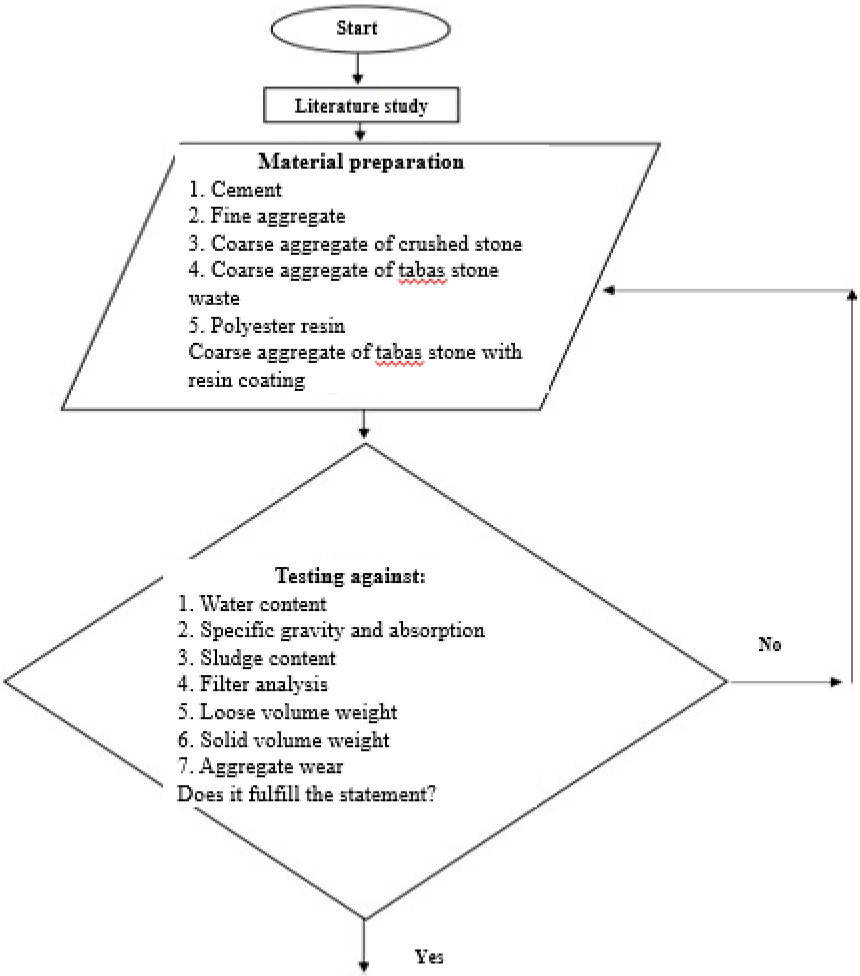
The water-resistant ability of this polyester resin makes it widely used in the shipping industry as a coating material for the manufacture of ship hulls.

Figure 1. Tabas stone

RESEARCH METHODS

The procedure or research steps carried out are like the flowchart shown in the following figure:



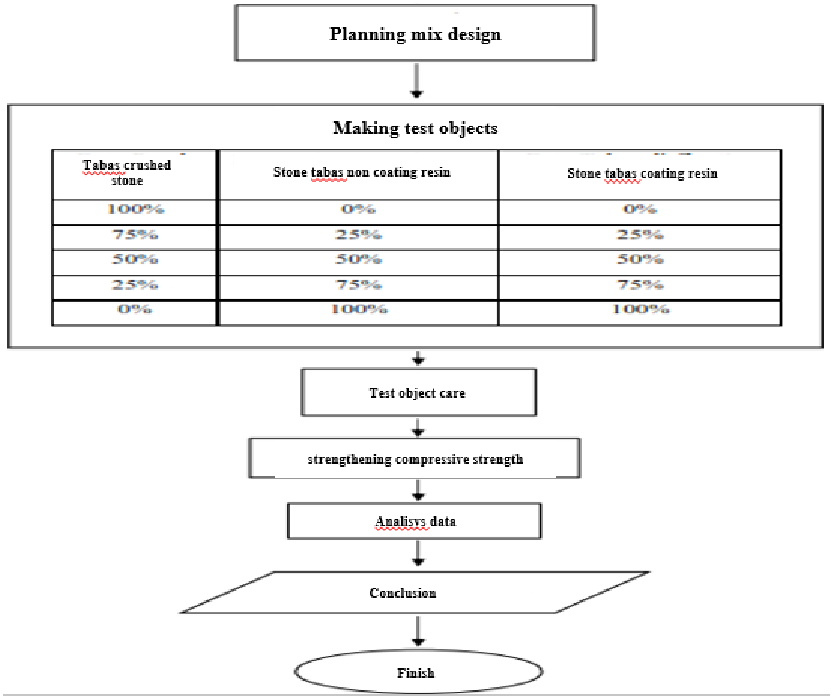


Figure 2. Flow chart

RESULTS AND DISCUSSION

Before making a concrete mix with the alternative material for coating tabas stone, several tests were carried out for coarse aggregate (gravel, coating stone), fine aggregate (sand). The test results can be seen in Tables 1 and 2 while for the gradation test can be seen in Figure 3.

Table 1 Results of fine aggregate testing

Test Type	Fine Aggregate
Water content	7,01
Water Absorption	4,82
Sludge levels	4,30
MHB	3,27
Volume Weight (friable)	1,43
Volume Weight (solid)	1,45
SSD Specific Gravity	2,40

The average SSD specific gravity value of 2.40 is included in the normal aggregate classification because it is in the range of 2.3-2.6 values. The absorption value of 4.82% indicates the aggregate's ability to absorb water from absolute dryness to surface dry saturation (SSD). The fine aggregate silt content of 4.30% has met the requirements for the silt content which may not exceed the value of 5%. The gradation for fine aggregate enters zone II according to SNI (National Standardization Agency, 2000). Fine Aggregate Fine Modulus (MHB) of 3.27 is in the range of 1.5-3.8 so that it meets the provisions of SK SNI-S-04-1989-F.

Table 2. Coarse aggregate test results

Test Type	Gravel	Tabas Stone	Tabas stone coating resin
Water content	5,04	1,59	1,18
Water Absorption	3,90	9,96	3,24
Sludge levels	0,98	0,61	0,95

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MHB	6,84	6,87	6,96
Volume Weight (friable)	1,35	1,37	1,40
Volume Weight (solid)	1,45	1,47	1,48
SSD Specific Gravity	2,61	2,17	2,16
Aggregate wear	34,44	37,30	35,94

In Table 2, it can be seen that the specific gravity of SSD is not too different between gravel, non-coated resin tabash and resin coated tababane. However, the percentage value of water absorption between coated resin tabas stone and non-coated resin tabas stone is very much different, which proves that resin-coated tabas stone has succeeded in reducing water absorption in tabas stone. Tabas aggregate and resin coating tabas stone have lower silt content compared to gravel. If the mud content above is less than 1%, it still meets the mud content requirements for coarse aggregate. The Fine Grain Modulus (MHB) values for gravel, non-coated resin tabas stone and resin coating stone respectively 6.84, 6.87 and 6.96 are still within the value range of 6-7.10 so that they meet the requirements according to SK SNI-S-04-1989-F. The aggregate condition of the resin-coated tabas stone and the gravel was not much different, in which 34.44% and 35.94% of the aggregate passed the No.12 filter.

Good gradation is very difficult to find directly from a rock crushing site. In order to get a good gradation, it is necessary to look for a combined aggregate gradation between fine aggregate and coarse aggregate. Aggregate gradation is the distribution of aggregate grain size variations. Aggregate gradation affects the size of the voids in the mixture and determines the workability (ease of work) and the stability of the mixture.

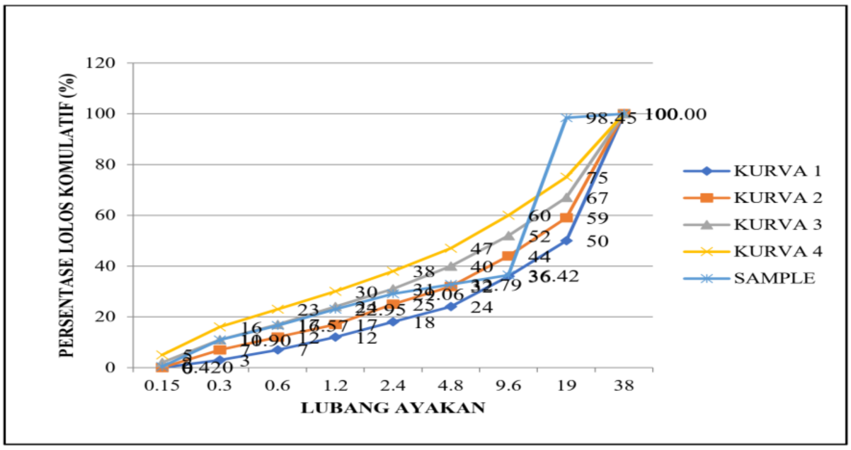

Figure 3. Combined aggregate gradation and coarse aggregate gradation limit zone size 40 mm

The concrete mix design guide in this study used the SNI 03-2834-2000 standard. The purpose of planning a concrete mix design is to get the appropriate amount of comparison sizes such as cement, coarse aggregate, fine aggregate and water. In Tables 3 and 4 it can be seen the proportions of each aggregate (coated and non-coated), cement and water for 1 m3 of concrete mix

Table 3. Proportions of mixed concrete mix for each variation per 1m^3 menggunakan agregat batu tabas non-*coating*

Variation Name	Tabas Percentage	Cement (kg)	Fine Aggregate (sand) (kg)	Coarse Aggregate (gravel) (kg)	Tabas coarse aggregate (kg)	Water (liter)
A1	0%	336,36	710,08	1146,74	0	156,81
T1	25%	336,36	710,08	860,06	260	183,78
T2	50%	336,36	710,08	573,37	519,43	210,75
T3	75%	336,36	710,08	286,69	779,17	237,72

T4	100%	336,36	710,08	0	1038,86	264,69

Table 4. Proportion of mixed concrete mix for each variation per 1 m3 using tabas aggregate in resin coating

Variation Name	Tabas Percentage	Cement (kg)	Fine Aggregate (sand) (kg)	Coarse Aggregate (gravel) (kg)	Tabas coarse aggregate (kg)	Water (liter)
A1	0%	336,36	710,08	1146,74	0	156,81
C1	25%	336,36	710,08	860,06	260	165,89
C2	50%	336,36	710,08	573,37	519,43	174,96
C3	75%	336,36	710,08	286,69	779,17	184,03
C4	100%	336,36	710,08	0	1038,86	193,11

Comparison of the compressive strength of concrete based on the percentage of substitution of coarse aggregate of tabas stone coated with non-coated at 7 and 28 days of age can be seen in the graphs in Figure 4 and Figure 5.

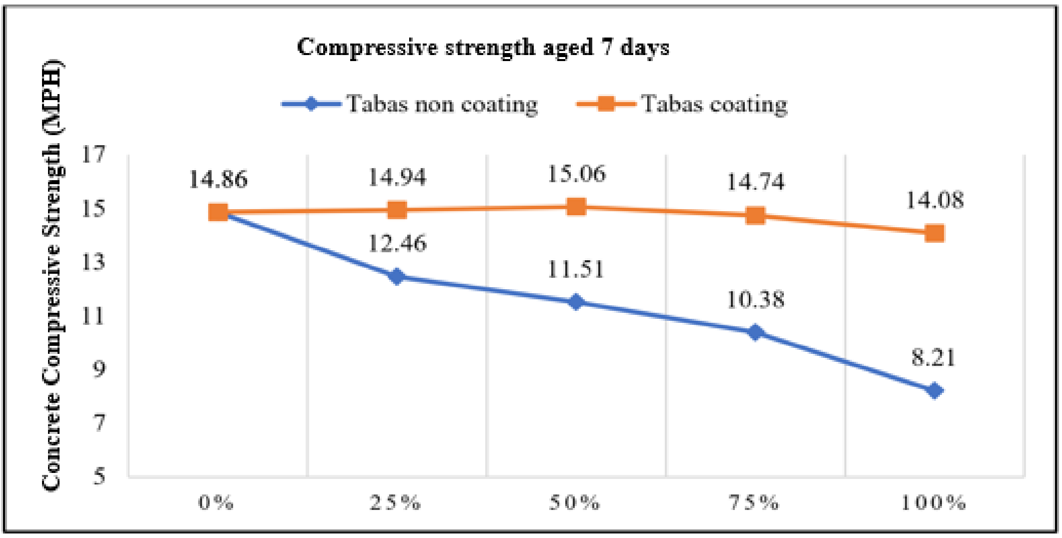

Figure 4. Graph of the relationship between the compressive strength of concrete aged 7 days with the substitution of non-coated tabas stone and resin coating

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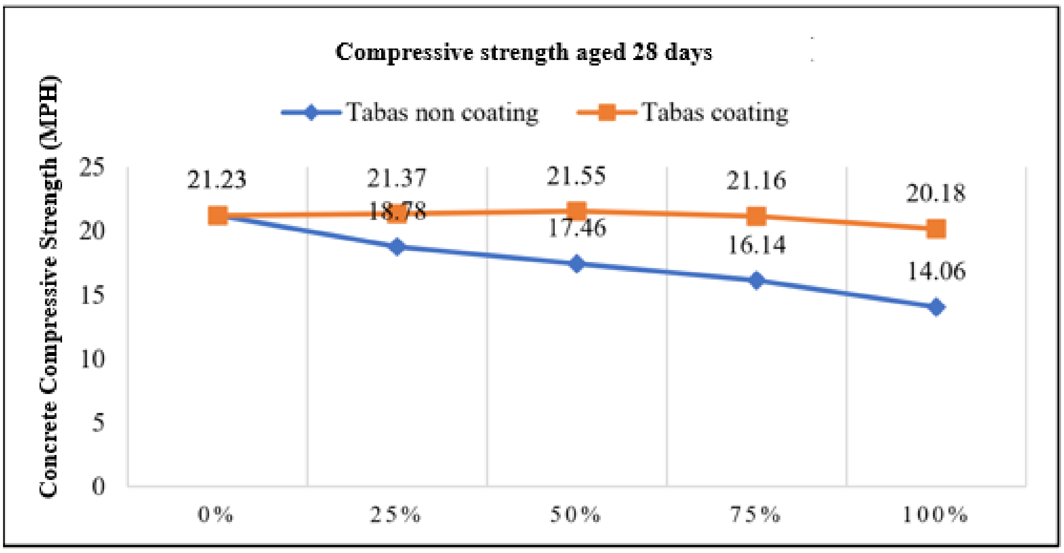

Figure 5. Graph of the relationship between the compressive strength of concrete aged 28 days with the substitution of non-coated tabas stone and resin coating

In Figure 5 it can be seen that the compressive strength of the non-coated tabex stone is lower than that of the stone coated with resin and gravel. This can occur due to differences in the quality of the wear and tear of the coarse gravel aggregate with resin-coated tabas stone and non-coated tabas stone. The results of the wear level test showed that the wear level of the non-coated tabas stone was 37.30% > that of the resin coating tabas stone, which was 35.94% > that of the gravel coarse aggregate, which was 34.44%. This causes most of the use of tabas stone aggregate coating resin as a concrete mixture also experiences a decrease in compressive strength because the value of concrete compressive strength is greatly influenced by the quality of the coarse aggregate used.

CONCLUSION

Comparison of the absorption value/level of water absorption in crushed stone, tabas stone and tabas stone coated with polyester resin was 3.90%; 9.96%; and 3.24%. This shows that the water absorption/absorption value of the tabas stone after being coated with polyester resin decreased by 67.5% compared to the uncoated tabas stone. The compressive strength values of concrete using 100% coarse aggregate of crushed stone at 7 days and 28 days were 14.86 MPa and 21.23 MPa, respectively. The maximum compressive strength value of concrete using coarse aggregate substitution with a coarse aggregate composition of 75% crushed stone and 25% non-coated tabas stone at the age of 7 and 28 days were 12.46 MPa and 18.78 MPa, respectively. The maximum compressive strength values of concrete using coarse aggregate substitution with a coarse aggregate composition of 50% crushed stone and 50% tabas stone coated with polyester resin at 7 and 28 days respectively were 15.06 MPa and 21.55 MPa. The increase in optimum compressive strength obtained from the compressive strength value with a variation of 50% by coating polyester resin on tabas stone was able to increase its compressive strength at 7 and 28 days respectively by 30.8% and 23.4% compared to non-coated tabas stone. While the increase in compressive strength for tabas stone coated with polyester resin was 1.35% and 1.51% higher compared to 100% coarse aggregate of crushed stone.

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