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A COMPARISON OF THE USE OF RECYCLED CONCRETE AS A SUBSTITUTE FOR COARSE AGGREGATE AND THE EFFECT OF ADDING SILICAFUME IN TERMS OF THE COMPRESSIVE STRENGTH OF CONCRETE

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ABSTRACT

One of the most widely used building materials on the planet is concrete. However, the production of concrete requires large amounts of natural resources such as sand and gravel. It is becoming increasingly difficult and costly to obtain these resources. Recycled concrete aggregate may be substituted for natural sand and gravel. Recycled concrete is the material used for RCA which would normally be discarded. It may help to reduce construction's impact on the environment by using RCA in concrete form. This could contribute to protecting natural resources, reducing greenhouse gas emissions from buildings, and, generating jobs in the recycling sector. The coarse aggregate was made up of 30% recycled concrete during the study.

Keywords: recycled concrete, silica fume, compressive strength

INTRODUCTION

Concrete is an important structural component in construction. Buildings such as water supply facilities, transportation infrastructure, and other buildings are also constructed using concrete as the main building material. In some cases, additives may be required to improve the performance of the concrete mix. The purpose of adding additives is to change the properties of concrete in the fresh state or after treatment. For example, they accelerate the hardening process, increase workability, increase compressive strength, reduce brittleness, and reduce hardened cracks (R. Rahmat and I. Hendriyani, 2016).

Concrete is made by mixing additional materials such as cement, water, coarse aggregate, fine aggregate, admixtures, fibers, and non-chemicals in certain proportions. Aggregate is the main material in the manufacture of concrete and pavement and is very important in the construction of infrastructure and infrastructure, so the need for concrete mix materials such as coarse and fine aggregates is increasing (A. Hitipeuw, S. Intan, and V. Johannes, 2018). The ratio of components in the mix is listed in order from the smallest grain size (soft) to the largest grain size, i.e. cement, sand, and gravel. If 1:2:3 cement is used in the concrete mix, it means that the mixed concrete contains 1 component of cement, 2 components of sand, and 3 components of gravel. The choice of materials in concrete production is very important in order to obtain the desired quality of concrete at the lowest possible cost. Several studies have been carried out to replace (natural) concrete materials with other materials, for example using demolition waste (concrete waste). The use of construction waste (old concrete) as an alternative has great research potential, as the recycling of concrete (old concrete) is still very little practiced and intensively tested (Soelarso, Baehaki, and F. S. Bur, 2016). The amount of construction waste is so large that the conservation of natural resources and reduction of natural resource depletion has become a global concern. One approach to reducing the consumption of natural resources in concrete materials is to take used (recycled) concrete and reuse it as coarse aggregate in the production of new concrete.

Recycled concrete is a concrete mix obtained by reusing previous materials. There are several differences in the quality of recycled aggregates, such as physical and chemical properties resulting in differences in the properties of the resulting concrete material, such as a decrease in compressive strength, tensile strength, and modulus. Research on normal concrete with the utilization of leftover concrete paste to be reused as aggregate has been conducted, among others, by (A. Junaidi, 2015), (A. Yusra, L. Opirina, and Irwansyah, 2019). From some of these studies, the results obtained are that the use of recycled concrete as a substitute for coarse aggregate plus addictive silica fume in normal concrete obtained the desired compressive strength by taking into account the amount of aggregate used.

Silica fume is a fine pozzolanic material (known as a combination of micro silica and silica fume) whose silica composition is largely derived from residues from the manufacture of blast furnaces or silicon or iron-silicon alloys (ASTM-C 1240). The addition of silica fume in the concrete mix produces concrete with high compressive strength (M. A. Rivai and R. Diastara, 2021). The strength produced by the addition of silica fume to concrete increases with each treatment or addition of silica fume, and at 21 days the aerated concrete has only normal concrete properties. After 7 days, the compressive strength of the porous concrete is too low to be used (L. Sihombing, 2017). The higher use of silica fume can give results that do not meet the slump value (Y. R. R. Saragi, 2014).

RESEARCH METHODS

The method used in this research is the experimental method in the laboratory.

The materials used in this research are:

- The fine aggregate used is sand from Binjai.
- The coarse aggregate used was gravel from Binjai and recycled concrete obtained from the project.
- The cement used is cement with the brand Padang type 1.
- The water used in this study came from the Concrete Laboratory, Department of Civil Engineering, Faculty of Engineering, Universitas Muhammadiyah Sumatera Utara.
- The admixture material used was silica fume.

Aggregate Inspection

When testing aggregates, both coarse and fine aggregates are carried out in the laboratory in accordance with the SNI Aggregate Testing Guidelines.

Trial Mix

Determine the percentage of each component of the concrete mix material in order to obtain a concrete mixture that meets the planned strength and durability, and has the appropriate workability to facilitate the work process.

Making Of Test Specimen

Samples were made using a cylindrical mold with a size of 15 cm x 30 cm as many as 16 pieces.

Slump Test

Measurement of slump height is done to determine the rigidity and workability of the concrete mix. The rigidity of the concrete mix indicates the amount of water used. The target slump planned according to the mix design is 60-180 mm. The slump test was conducted following the standards set by SNI 03-2834-2000.

Compressive Test

Compressive strength testing is carried out according to SNI 03-2491-2002 standards. The test was conducted using a compression testing machine with a capacity of 1500 KN. The sample is placed vertically on the tester, then the compressive load is applied evenly from above along the cylinder. Before testing, the samples were first weighed to determine the specific gravity of the concrete.

RESULTS AND DISCUSSIONS

Slump Test Results

The slump test is carried out with an Abrams cone by filling the Abrams cone with fresh concrete in 3 layers, each layer is approximately 1/3 of the contents of the cone in each layer puncturing 25 times, the puncturing stick must enter the bottom of each layer after filling is complete, flatten the cone surface and then lift the mold with a distance of 300 mm within 5 ± 2 seconds without lateral or torsional movement.

Table 1. Slump test results

Variations	Slumps Hight (cm) (cm))
Normal Concrete	15
Recycle 30% + Silica Fume 25 %	24.5
Recycle 30% + Silica Fume 27 %	24
Recycle 30% + Silica Fume 33 %	22.5
Recycle 30% + Silica Fume 0%	25
Normal + Silica Fume 27%	23.5

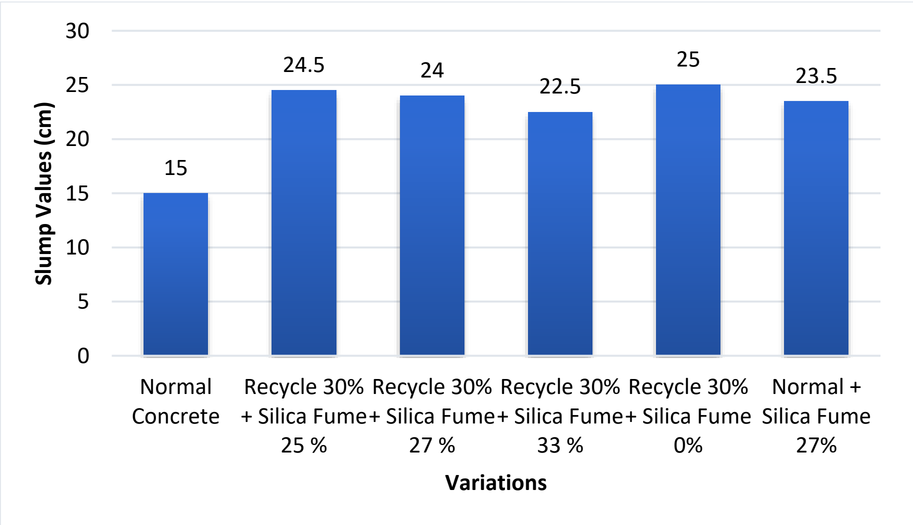

Figure 1: Slump Test Results

Based on Table 1 comparison of the slump value of normal concrete, a concrete mixture of 30% residual concrete + 25% silica fume, a concrete mixture of 30% residual concrete + 27% silica fume, a concrete mixture of 30% residual concrete + 33% silica fume, a concrete mixture of 30% residual concrete, a concrete mixture of 27% silica fume, in concrete with a mixture of 30% residual concrete obtained the highest slump value of 25 cm, while in concrete mixtures added with recycled concrete and silica fume decreased the slump value. As shown in Figure 1, the slump value graph can be seen.

Compressive Strength Test Results

Concrete compressive testing is carried out using a compressive strength tester with a capacity of 1500 KN when the concrete has passed 28 days. The samples tested were 16 pieces in the form of cylinders with a diameter of 15 cm and a length of 30 cm.

Figure 2. Compressive Strength Testing Equipment

Table 2. Compressive strength test results

Variations	Average Compressive Strength (MPa)
Normal Concrete	23.22
Recycle 30% + Silica Fume 25 %	24.28
Recycle 30% + Silica Fume 27 %	26.84
Recycle 30% + Silica Fume 33 %	23.61
Recycle 30% + Silica Fume 0%	23.73
Normal + Silica Fume 27%	28.40

The results of Table 2. show that the addition of 30% concrete residue + silica fume at the age of 28 days concrete is able to increase the compressive strength of concrete. Concrete with optimum compressive strength occurs in a concrete mixture of 30% concrete residue + silica fume 27% with a compressive strength of 31.08 MPa. The lowest average compressive strength test result is found in a concrete mixture of 30% concrete residue + silica fume 27 at 23.73 MPa.

According to the research (D. Pradhan and D. Dutta, 2013), that the maximum compressive strength was obtained at 20% silica fume replacement level and thereafter the compressive strength decreased. There is a significant increase in the compressive strength of concrete using silica fume additives due to the high pozzolanic properties of silica fume and its void-filling ability (N. K. Amudhavalli and J. Mathew, 2012).

Compared to the compressive strength of ordinary concrete with recycled admixtures and silica fume, concrete with recycled admixtures and concrete with recycled concrete admixtures and silica fume show differences in the increase and decrease in compressive strength. Based on the average compressive strength of concrete with different additives, a graphical figure of the average compressive strength of concrete can be obtained as follows:

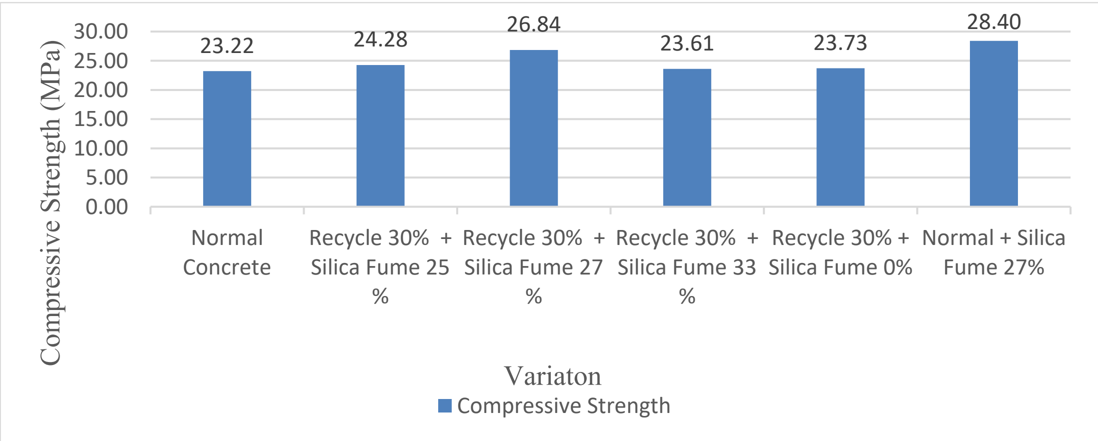

Figure 3. Compressive Strength Test Results

In Figure 3, the lowest compressive strength was obtained in normal concrete with a compressive strength of 23.22 MPa, and the highest compressive strength was obtained in concrete with the addition of 27% silica fume with a compressive strength of 28.40 MPa, while concrete with the addition of 30% concrete residue + 27% silica fume had a compressive strength value of 26.84 MPa. Comparison of compressive strength values between ordinary concrete and silica fume admixture concrete has an increase of 5.18 MPa, while the comparison between normal concrete and concrete with recycle admixture obtained an increase in compressive strength of 0.51 MPa, and the optimum compressive strength was obtained by the silica fume variation of 27%.

The addition of silica fume can increase the compressive strength of concrete significantly, but the use of silica fume above 27% of the compressive strength of concrete begins to decrease gradually. The addition of recycled concrete can increase the compressive strength of concrete by 2% of normal concrete. This is in line with the results of the research (Soelarso, Baehaki, and F. S. Bur, 2016) It can be seen that the compressive strength decreases as the frequency of using concrete waste increases. This is due to the variability of waste quality causing the resulting concrete materials to have different properties and tend to have lower compressive strength and modulus. According to research (P. H. Simatupang and J. K. Nasjono, 2017). It can be concluded that as the silica fume content increases, the compressive strength value increases until it reaches the optimum compressive strength value, and the compressive strength value will gradually decrease until it reaches a constant value.

As seen in Figure 3., it can be concluded, as follows:

- Normal concrete added with 27% silica fume has an increase in compressive strength of 18% of the normal concrete compressive strength value.
- The addition of 30% recycled concrete as coarse aggregate only slightly increases the compressive strength of concrete compared to normal concrete by 2%.
- The addition of 30% recycled concrete + 7% silica fume has an increase of 13% from the compressive strength value of normal concrete.
- The addition of 30% recycle concrete + 33% silica fume only slightly increases the compressive strength of concrete compared to normal concrete by 2%.
- In the variation of concrete mix recycle 30% + silica fume 33% there is a decrease of 14% from the addition of concrete recycle 30% + silica fume 27%.

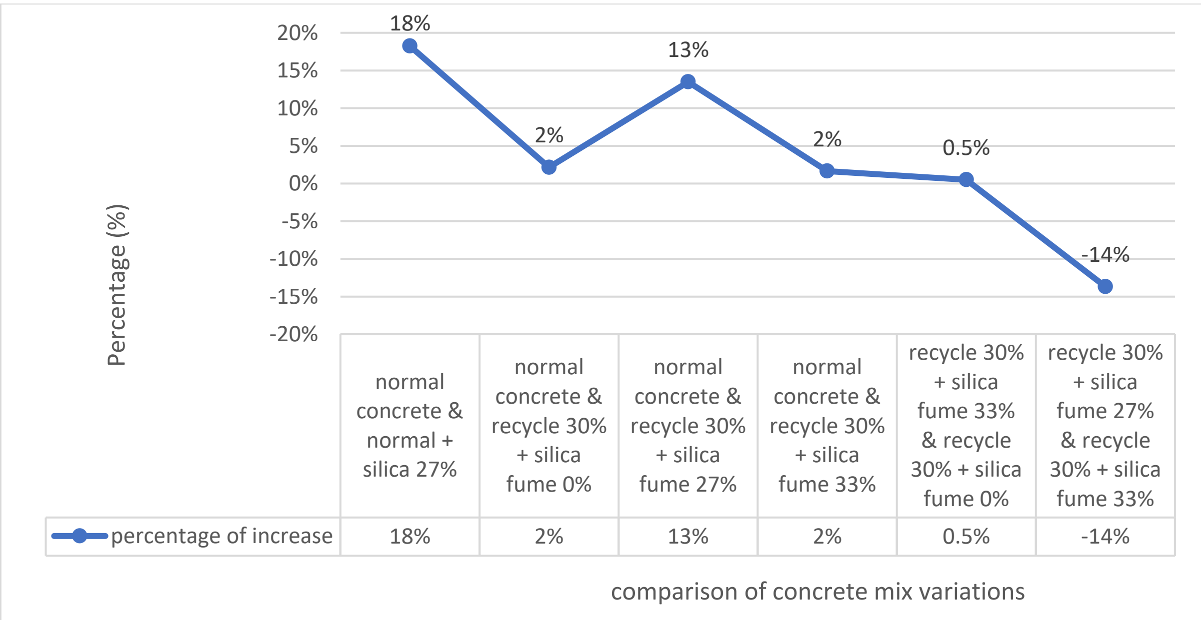

Figure 4. Comparison of Concrete Mix Variations

CONCLUSIONS

From the research results, several conclusions can be drawn, among others, as follows:

- The highest slump test value is found in the concrete variation with a mixture of 30% recycled concrete with a value of 25 cm. While the lowest slump test value is in the normal concrete variation with a value of 15 cm.
- The results showed that the addition of concrete residue or recycled concrete as a coarse aggregate greatly influenced the results of the slump test. The addition of 30% concrete residue resulted in an increase in the slump value by 66.67%.
- The highest compressive strength test value is found in the 27% silica fume mixture concrete variation with a compressive strength of 28.40 MPa. While the lowest compressive strength value is obtained in the normal concrete variation with a compressive strength value of 23.22 MPa.
- The results showed that the addition of concrete residue or recycled concrete as coarse aggregate slightly increased the compressive strength of the concrete. The addition of 30% concrete residue resulted in a 2% increase in compressive strength.
- Based on the results of the study, the use of silica fume is able to increase the compressive strength of concrete by 22% of normal concrete.
- Based on the results of the study, the addition of concrete residue and silica fume varies, indicating that the use of too much silica fume can increase the compressive strength to the optimum value, then it will decrease constantly.

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