ASTONJADRO

pISSN 2302-4240
eISSN 2655-2086

Volume 15, Issue 1, March 2026, pp.0309-0318
DOI: http://dx.doi.org/10.32832/astonjadro.v15i1.21266 http://ejournal.uika-bogor.ac.id/index.php/ASTONJADRO

The Effect of the Variation of the Addition of Concrete Waste as a Substitute for Aggregate on the Compressive Strength of Concrete

Rasiful Aqli, Faris Rizal Andardi, Sandi Wahyudiono

Department of Civil Engineering, University of Muhammadiyah Malang, Malang, INDONESIA

E-mail: sandi@umm.ac.id

| Submitted: August 16, 2025 | Revised: October 09, 2025 | Accepted: December 10, 2025 |

| Published: March 04, 2026 |

ABSTRACT

This study investigates the utilization of recycled concrete aggregate as a replacement for natural aggregate in concrete mixtures. Various mixture variations were created by replacing both coarse and fine aggregates with recycled concrete waste at percentages of 20%, 40%, 60%, and 80%. Additionally, 10% rice husk ash was added as a partial replacement for cement. Material and mix design tests were conducted to achieve a target concrete compressive strength of 30 MPa. Cylindrical test specimens were cured for 28 days and then tested for their compressive strength. The test results were analyzed to determine the effect of recycled concrete waste on the concrete's compressive strength. This research is expected to provide a basis for the effective and sustainable use of recycled concrete waste in the construction industry.

Keywords: recycled concrete waste, concrete compressive strength, recycled aggregate, waste utilization.

INTRODUCTION

The construction industry has a crucial role in the country's economic growth, but it also generates large amounts of waste, including concrete waste. Concrete has now become one of the main materials in buildings that is very important to meet the needs of the property and civil building industries [1]. The increasing volume of concrete waste from construction and demolition of buildings is a serious problem related to environmental management and resource sustainability. The contribution of concrete waste to construction waste piles is quite small [2]. Concrete waste, if left untreated, will damage the environment without the handling of the waste [3]. Concrete is a construction material consisting of constituent materials in the form of cement, aggregate, water and other additives [4]. Normal concrete is concrete that has a content weight of 2200–2500 kg/m³ using natural aggregates that are broken down or unbroken [5].

In this situation, recycling concrete waste is a promising solution to reduce the negative impact of the construction industry on the environment. The recycling process converts concrete waste into recycled aggregates, which have the potential to be reused in new concrete mixes. The utilization of recycled concrete waste not only reduces the amount of waste that needs to be disposed of, but also reduces the need for the extraction of natural aggregates such as sand and gravel, which often causes environmental damage. Green concrete supports three pillars of sustainability: environmental, economic, and social impact [6]. The reuse of concrete waste will increase the material use life of the waste itself [7]. According to Scott, some of the cement can be replaced with rice husk ash with the aim of reducing cement use so as to minimize the impact of cement production on global warming due to CO2 emissions [8]. The use of rice husks can reduce waste from rice milling [9].

As one of the main factors in structural design, compressive strength determines how much load a concrete building can withstand and how safe it is. The replacement of natural aggregates with recycled concrete waste can affect the compressive strength of concrete due to differences in physical and mechanical characteristics between the two types of aggregates.

Research on the effect of recycled concrete waste on the compressive strength of concrete has yielded mixed findings. The advantages of concrete compared to other construction materials are fireproof, durable, minimal maintenance, high compressive strength and easy to form when still fresh [10]. The results of the study varied depending on the quality of the recycled concrete waste

used, the percentage of replacement of natural aggregates with recycled concrete waste, and the design of the concrete mixture applied. Therefore, further research is needed to comprehensively understand how the use of recycled concrete waste affects the compressive strength of concrete. A better understanding of this will help in the more effective and safe utilization of recycled concrete waste in the construction industry.

The Indonesian National Standard (SNI) plays an important role in ensuring the quality and performance of concrete used in construction in Indonesia. SNI establishes the requirements and testing methods that must be met by concrete materials, including aggregates. This study will refer to the relevant SNI standards to ensure that the compressive strength testing of concrete is done correctly and that the results can be compared with other studies using the same standard. There are various types of testing methods to obtain concrete compressive strength values, including concrete compressive strength with the hammer test method and concrete compressive strength with compression test, the hammer test method is used for non-destructive concrete compressive strength test and the compression test method is used for destructive concrete compressive strength test [4].

One of the relevant SNI standards is SNI 1974:2011 [11], which discusses how to test the compressive strength of cylindrical concrete. This standard provides detailed guidance on concrete test piece preparation, test procedures, and compressive strength calculations. In addition, the recycling aggregate testing will also refer to the SNI 03-1969-2008 [12] standard on Methods of testing specific gravity and absorption of coarse aggregate water, and SNI 03-1970-2008 [13] on Methods of testing specific gravity and absorption of fine aggregate water. By following this standard, this study will produce accurate and reliable data on the effect of recycled concrete waste on the compressive strength of concrete. The effect of material exploitation will damage the environment, therefore, there needs to be alternative materials to replace coarse and fine aggregates in concrete [14].

This study aims to investigate in depth the effect of the use of recycled concrete waste as a substitute for natural aggregates on the compressive strength of concrete. In this study, several variations of the concrete mixture will be made by changing the percentage of recycled concrete waste used. This variation of the mixture will allow a comprehensive analysis of how changes in the proportion of recycled concrete waste affect the compressive strength of concrete. Specifically, this study will use a mixture of recycled concrete waste consisting of recycled coarse aggregates of 20, 40, 60% and 80%, recycled fine aggregates of 20, 40, 60% and 80%, as well as a combination of coarse aggregates and recycled fine aggregates of 20, 40, 60% and 80%.

Through the variation in the percentage of recycled concrete waste in concrete mixtures, this study is expected to provide a better understanding of the potential of recycled concrete waste as an alternative material in concrete mixtures. This research is also expected to identify the optimal percentage of recycled concrete waste to achieve adequate concrete compressive strength. This information is critical for the development of effective applications of recycled concrete waste in the construction industry.

The results of this research are expected to make a valuable contribution to the development of more sustainable and environmentally friendly construction practices in Indonesia. The widespread utilization of recycled concrete waste can reduce dependence on limited natural resources and reduce the amount of waste discharged into the environment.

RESEARCH METHODS

This research began by conducting an in-depth literature study on the use of concrete mixtures in various applications. This literature study involves the collection of a variety of references, including scientific books, research journals, and regulations closely related to the topics discussed in this study. The goal is to build a strong theoretical foundation and understand previous research that has been done in this field.

The next stage in this research is the collection of materials needed for the manufacture of concrete test pieces. Concrete waste is collected and then processed through crushing to obtain coarse aggregates and fine aggregates with granules/gradients sizes that conform to applicable standards

pISSN 2302-4240
eISSN 2655-2086
Volume 15, Issue 1, March 2026, pp.0309-0318
DOI: http://dx.doi.org/10.32832/astonjadro.v15i1.21266 http://ejournal.uika-bogor.ac.id/index.php/ASTONJADRO

[15]. Gradation is the distribution of the proportion of the size of the aggregate granules in a concrete mixture in addition, for natural aggregate materials and cement to be used as a comparison, material testing is carried out at the civil engineering laboratory of the University of Muhammadiyah Malang.

Testing materials in the laboratory aims to determine the physical and mechanical characteristics of the materials to be used in concrete mixtures. This testing includes:

- Gradation of coarse and fine aggregates in accordance with SNI 03-1968-1990 [15].
- Specific gravity and absorption of coarse aggregate water in accordance with SNI 03-1969-2008 [12].
- The specific gravity and absorption of fine aggregate water are in accordance with SNI 03-1970-2008 [13].
- The aggregate sludge content is in accordance with SNI 03-1971-1990 [16].

The results of these tests are important to ensure that the materials used meet the good quality requirements for the concrete mixture.

Once the material characteristics are known, the next step is to design the proportion of the concrete mix (mix design) for the planned concrete with a compressive strength (f'c) of 30 MPa. The calculation of the mix design is carried out by taking into account the results of material testing, such as the gradation of coarse and fine aggregates, the cement water factor, and the type and brand of cement used. One of the indicators of good concrete quality can be seen from the results of the compressive strength test, where the compressive strength of the concrete produced should not be lower than the compressive strength of the planned concrete in the mix design [17] In this study, 10% of the cement weight will be replaced with rice husk ash. The purpose of the mix design is to obtain a concrete mixture that is economical but still meets the desired compressive strength requirements. Thus, a mix design is needed so that the concrete can meet the specified engineering specifications [18].

After the composition of the concrete mixture is determined, a cylindrical formwork preparation with standard dimensions for the test object is carried out. The formwork is smeared with formwork oil to facilitate the removal of the test specimen after the concrete hardening process is completed. The materials needed for each mixture, including natural coarse aggregates, natural fine aggregates, cement (with 10% replacement of rice husk ash), recycled fine aggregates, and recycled coarse aggregates, are taken to the civil engineering laboratory of the University of Muhammadiyah Malang for the casting process.

The casting process or manufacture of the test specimen is carried out based on the composition of the mixture that has been pre-designed. For each stirring of the concrete mixture, a slump test is carried out in accordance with SNI 1972:2011 [19] on the Concrete Slump Test Method to measure the consistency or ease of fresh concrete workmanship. For each variation of the concrete mixture studied, as many as nine standard size cylindrical test pieces were made. Casting is done in stages to ensure that the concrete is well filled in the formwork. The variations of the mixture used are:

- Recycled coarse aggregates only: 60% and 80%
- Recycled fine aggregates only: 60% and 80%
- Combination of coarse aggregate and fine aggregate recycled: 60% and 80%

After the casting process of the test pieces is completed, the formwork is carefully opened one by one. Then, the concrete test object that has been removed from the formwork is soaked in a water bath for 28 calendar days for the curing process. This soaking process is important to ensure that the cement hydration process runs perfectly so that the concrete reaches optimal strength.

After the 28-day treatment period ends, the concrete test piece is lifted from the immersion bath and the surface is dried. Furthermore, compressive strength testing was carried out in accordance with SNI 1974:2011 [11]. Of the nine test specimens made for each mixture variation, three test specimens are used for compressive strength testing. Testing is carried out in stages for each variation of the concrete mixture that has been made.

In the final stage of the study, an analysis and comparison of compressive strength test results of each variation of concrete mixture was carried out. Compressive strength data from each mixture was compared to determine the effect of the use of recycled concrete waste with different percentages on the compressive strength of concrete. The results of this analysis will be the basis for drawing conclusions and providing recommendations regarding the use of recycled concrete waste in concrete mixtures.

RESULT AND DISCUSSION

Effect of Recycled Concrete Waste on the compressive strength of concrete

The test was carried out on a standard cylindrical concrete sample measuring 15 cm in diameter and 30 cm in height. These samples are tested after being treated for 28 days, which is the typical time the concrete reaches sufficient strength to be evaluated. Testing at this age provides an early picture of the mechanical performance of concrete under field conditions. The results of this test will be the basis for assessing the quality and potential use of the concrete mixture being studied. The compressive strength of concrete is a key parameter to know and can give an idea of almost all of the other mechanical properties of concrete [20].

Analysis of the compressive strength of concrete is an important process in designing and manufacturing quality concrete [21]. Each type of test is carried out in accordance with the rules set out in the Indonesian National Standard (SNI). The use of this standard ensures that the method of testing and the results obtained are trustworthy and compared with other studies in Indonesia. By following standards, this research data has a strong scientific basis and can be accounted for. Compliance with standards also helps in understanding the position of this research in the context of concrete science and technology at the national level.

To measure the strength of concrete in resisting pressure, SNI 1974:2011 [11] is used. This standard describes the steps of preparing the test object, by applying pressure in stages, and calculating the compressive force based on the maximum load that the test object can hold. The results of this test show how strong concrete is in withstanding pressures from above, such as the weight of the building itself. Compressive strength is one of the most important properties to determine the safety of a structure.

Based on laboratory testing on the compressive strength of concrete with a mixture of recycled Crude Aggregate (AK) based on the percentage of the table below and 10% of the husk ash of portland cement and the rest is natural aggregate where each mixture of 3 test objects, the following results were obtained:

Table 1. Recycled Coarse Aggregate Mix Press Test

Mixed type	Weight (Kg)	Compressive Strength (Mpa)
AK 0%.1	12,45	30,34
AK 0%.2	12,50	31,54
AK 0%.3	12,55	29,02
AK 20%.1	12,35	29,21
AK 20%.2	12,30	26,07
AK 20%.3	12,40	27,99
AK 40%.1	11,90	26,19
AK 40%.2	12,20	28,77
AK 40%.3	12,00	27,53
AK 60%.1	12,25	29,67
AK 60%.2	11,90	30,57
AK 60%.3	12,00	30,31
AK 80%.1	11,95	27,98
AK 80%.2	11,85	25,22
AK 80%.3	11,90	28,71

pISSN 2302-4240
eISSN 2655-2086
Volume 15, Issue 1, March 2026, pp.0309-0318
DOI: http://dx.doi.org/10.32832/astonjadro.v15i1.21266 http://ejournal.uika-bogor.ac.id/index.php/ASTONJADRO

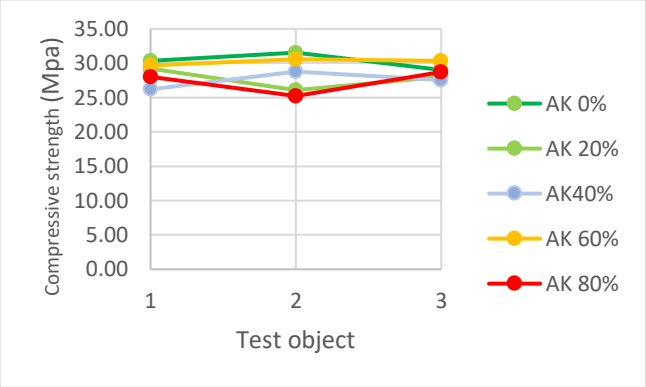

Figure 1. Graph of the results test of the recycled coarse aggregate mixture

Based on the data from the test results of the compressive strength of concrete with variations of Recycled coarse agregate(AK) mixtures, it was obtained that the mixture without Recycled coarse agregate(0% AK) produced the highest compressive strength with values of 30.34 MPa, 31.54 MPa, and 29.02 MPa, respectively, and an average of around 30.30 MPa. The 20% AK mixture showed a decrease in compressive strength with values of 29.21 MPa, 26.07 MPa, and 27.99 MPa, and an average of about 27.76 MPa. In a 40% AK mixture, the compressive strength obtained was 26.19 MPa, 28.77 MPa, and 27.53 MPa with an average of about 27.50 MPa, which shows a fairly stable value although slightly lower than that of 20% AK. Interestingly, in the 60% AK mixture, the compressive strength values increased again to 29.67 MPa, 30.57 MPa, and 30.31 MPa, with an average of about 30.18 MPa, almost matching the results of the Recycled coarse agregate-free mixture. However, in an 80% AK mixture, the compressive strength decreases again to 27.98 MPa, 25.22 MPa, and 28.71 MPa with an average of about 27.30 MPa. In general, the graph shows a fluctuating pattern where the compressive strength decreases at the addition of 20% and 40% Recycled coarse agregate, increases at 60%, then decreases again at 80%. This shows that the addition of Recycled coarse agregatein a certain proportion (specifically 60%) is still able to maintain even close to normal concrete strength, but an addition that is too high such as 80% can significantly reduce the compressive strength of concrete.

Based on the results of the compressive strength test on the mixed test specimen of the variation of the recycled coarse aggregate, the use of the mixed variation of the 60% recycled coarse aggregate has a greater yield than the other variations, which is 30.57 Mpa. While the use of the coarse aggregate mixture variation was 80% lower than the other variation, which was 25.22 Mpa, the use of the 60% mixed variation showed better performance compared to other types of mixtures. This shows that the proportion of recycled coarse aggregates used in concrete mixtures greatly influences the compressive strength produced. In the 0% mixture variation or without recycled aggregates, the compressive strength produced is also very high, reaching 31.54 MPa, indicating that normal concrete still has superior performance. However, test results show that mixtures with 60% recycled coarse aggregate are able to approach or even equal the strength of normal concrete, so they can be an effective alternative in efforts to utilize recycled materials. On the other hand, the addition of recycled aggregates excessively, such as in 80% mixtures, actually significantly reduces the compressive strength. The mixture variations of 20% and 40% produce moderate compressive strength, with average values of about 27.76 MPa and 27.50 MPa, respectively. Thus, it can be concluded that the use of recycled coarse aggregates in concrete mixtures is still possible to produce high-strength concrete, especially at the proportion of 60%, but must still pay attention to the optimal limits of its use so as not to degrade the overall structural quality of concrete.

Based on laboratory testing on the compressive strength of concrete with a mixture of recycled fine aggregates (AH) based on the percentage of the table below and husk ash 10% of portland cement and the rest is natural aggregate where each mixture of 3 test objects, the following results were obtained:

Table 2. Recycled Fine Aggregate Mix Press Test

Mixed type	Weight (Kg)	Compressive Strength (Mpa)
AH 0%.1	12,45	30,34
AH 0%.2	12,50	31,54
AH 0%.3	12,55	29,02
AH 20%.1	12,05	25,74
AH 20%.2	12,00	24,94
AH 20%.3	12,05	24,97
AH 40%.1	12,25	28,05
AH 40%.2	12,10	30,38
AH 40%.3	12,20	26,73
AH 60%.1	11,90	22,93
AH 60%.2	11,85	22,41
AH 60%.3	11,85	23,50
AH 80%.1	12,30	21,80
AH 80%.2	12,10	21,04
AH 80%.3	12,35	22,81

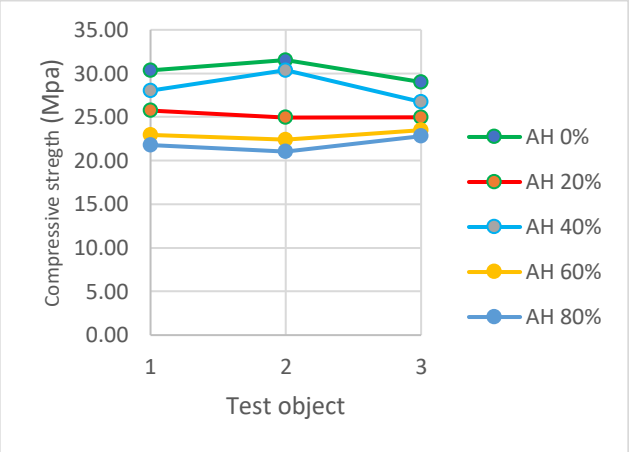

Figure 2. Graph of the results test of the recycled fine aggregate mixture

Based on the results of the compressive strength test of concrete with a variation of recycled fine aggregate (AH) mixture, it was obtained that the mixture without recycled fine aggregate (AH 0%) produced the highest compressive strength, which was 30.34 MPa, 31.54 MPa, and 29.02 MPa, with an average of about 30.30 MPa. In the 20% AH mixture, there was a significant decrease in compressive strength, with results of 25.74 MPa, 24.94 MPa, and 24.97 MPa, respectively, resulting in an average of about 25.22 MPa. Meanwhile, in the 40% AH mixture, the recompressive strength increases to 28.05 MPa, 30.38 MPa, and 26.73 MPa, with an average of about 28.38 MPa, suggesting that the addition of recycled fine aggregate up to 40% is still capable of producing compressive strength close to normal concrete. However, in the 60% AH mixture, the compressive strength values again decreased to 22.93 MPa, 22.41 MPa, and 23.50 MPa, with an average of about 22.95 MPa. A sharper decline occurred in the 80% AH mixture, with compressive strengths of 21.80 MPa, 21.04 MPa, and 22.81 MPa, averaging about 21.88 MPa, which was the lowest value in all test variations. Overall, the data show that the use of recycled fine aggregates in concrete mixtures has an effect on the compressive strength produced, where the maximum proportion that is still able to maintain the strength of the concrete is in the range of 40%. The use of recycled aggregates above these proportions tends to significantly reduce the compressive strength, so it needs to be limited to maintain the structural quality of concrete.

pISSN 2302-4240
eISSN 2655-2086
Volume 15, Issue 1, March 2026, pp.0309-0318
DOI: http://dx.doi.org/10.32832/astonjadro.v15i1.21266 http://ejournal.uika-bogor.ac.id/index.php/ASTONJADRO

This shows that the use of recycled fine aggregates in concrete mixtures is still possible to produce high compressive strength when used in the right proportions. In mixtures without recycled aggregate (0% AH), the compressive strength produced is also relatively high with a value of 31.54 MPa, making it a reference for normal concrete performance. Meanwhile, mixtures with 20% recycled fine aggregates experienced a significant decrease in compressive strength, with an average value of about 25.22 MPa. The 60% and 80% mixtures even showed further declines, with average values of about 22.95 MPa and 21.88 MPa, respectively. From these results, it can be concluded that the addition of recycled fine aggregates of more than 40% begins to significantly reduce the quality of concrete. Therefore, the proportion of the mixture of 40% is the optimal limit that can still keep the strength of concrete close to normal concrete standards, as well as potentially an environmentally friendly alternative in recycling materials without sacrificing the overall structural strength of concrete.

Based on laboratory testing on the compressive strength of concrete with a mixture of recycled fine aggregate (AH) and recycled Crude Aggregate (AK) based on the percentage of table below and 10% husk ash from portland cement and the rest is natural aggregate where each mixture of 3 test objects, the following results were obtained:

Table 3. Fine Aggregate & Recycled Coarse Aggregate Mix Press Test

Mixed type	Weight (Kg)	Compressive Strength (Mpa)
AH 0%.1	12,45	30,34
AH 0%.2	12,5	31,54
AH 0%.3	12,55	29,02
AH AK 20%.1	12,45	29,77
AH AK 20%.2	12,60	28,15
AH AK 20%.3	12,35	26,49
AH AK 40%.1	12,55	23,86
AH AK 40%.2	11,95	24,68
AH AK 40%.3	12,35	23,21
AH AK 60%.1	11,95	23,38
AH AK 60%.2	12,05	22,36
AH AK 60%.3	11,80	22,48
AH AK 80%.1	12,05	23,10
AH AK 80%.2	11,75	22,08
AH AK 80%.3	11,90	21,26

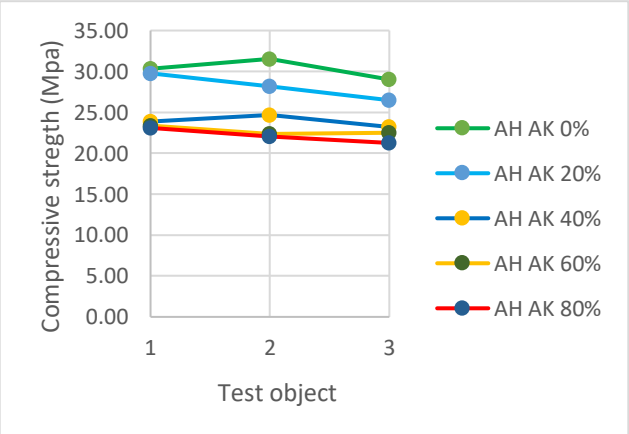

Figure 3. Graph of the results test of the mixture of fine aggregate and recycled coarse aggregate

Testing data of concrete mixtures with variations in the use of recycled fine aggregate (AH AK) showed a clear pattern in the weight and compressive strength of concrete. For mixtures without recycled aggregates (0% AH), the weight of the mixture ranges from 12.45 to 12.55 kg with a relatively high compressive strength, which is between 29.02 to 31.54 Mpa. When recycled aggregate is used as much as 20% (AH AK 20%), the weight of the mixture is still stable in the range of 12.35 to 12.60 kg, but the compressive strength of concrete begins to decrease, which is in the range of 26.49 to 29.77 Mpa. At an increase in the percentage of recycled aggregate to 40% (AH AK 40%), the weight of the mixture varied slightly from 11.95 to 12.55 kg, while the compressive strength decreased further, ranging from 23.21 to 24.68 Mpa. Furthermore, in a mixture with 60% recycled aggregate (AH AK 60%), the weight of the mixture is around 11.80 to 12.05 kg and the compressive strength is reduced to between 22.36 to 23.38 Mpa. Finally, in the mixture with the highest percentage of recycled aggregate, which is 80% (AH AK 80%), the weight of the mixture is in the lowest range of 11.75 to 12.05 kg, with the lowest compressive strength of concrete, which is between 21.26 to 23.10 Mpa. From these data, it can be concluded that the higher the percentage of recycled fine aggregates used in concrete mixtures, the compressive strength of concrete tends to decrease, although the weight of the mixture is relatively stable and there is little variation.

Based on the results of compressive strength tests on the test specimen of recycled coarse aggregate and recycled fine aggregate variations, the use of a mixture variation of recycled coarse aggregate and 20% recycled fine aggregate mixture had a greater yield than the other variations of 29.77 Mpa. Meanwhile, the use of a mixture of recycled coarse aggregate and recycled fine aggregate is 80% lower than the other variation, which is 21.26 Mpa. This shows that the addition of recycled aggregate at a level of 20% can still maintain the strength of concrete quite well, close to a mixture without recycled aggregates. However, an increase in the percentage of recycled aggregates up to 80% leads to a significant decrease in the compressive strength of concrete, which indicates that too much use of recycled aggregates can reduce the quality and strength of the material. In general, the weight of the concrete mixture at various variations in the percentage of recycled aggregate is relatively stable, ranging from 11.75 to 12.60 kg, but the decrease in compressive strength that occurs indicates a negative effect of the increase in the content of recycled aggregate on the durability of concrete. Therefore, the use of recycled aggregates needs to be optimized so that the strength of concrete remains in line with standards and meets construction needs.

CONCLUSION

Based on the results of the compressive strength test given, the following conclusions can be drawn:

Variations of Recycled Coarse Aggregates:

The use of recycled coarse aggregate with a 60% mixture variation yields the highest compressive strength (30.57 MPa), the use of recycled coarse aggregates with 80% mixed variation yields the lowest compressive strength (25.22 MPa), overall, the 60% mixed variation gave better results than other variations, suggesting that increasing the proportion of recycled coarse aggregate to some extent can increase compressive strength.

Variations of Recycled Coarse and Fine Aggregates:

The use of a mixture of recycled coarse and fine aggregates with a 20% variation results in the highest compressive strength (29.77 MPa), the use of recycled coarse and fine aggregate mixtures with 80% variation results in the lowest compressive strength (21.04 MPa), a 20% mix variation shows better performance than other variations, indicating that the combination of recycled coarse and fine aggregates in the right proportions can produce good compressive strength, but high proportions can significantly degrade performance.

Variations of Recycled Fine Aggregates:

The use of recycled fine aggregates with a 40% mixture variation results in the highest compressive strength (30.38 MPa), the use of recycled fine aggregates with a 20% mixture variation results in the lowest compressive strength (21.04 MPa), the 40% mix variation gives better results than other

variations, suggesting that recycled fine aggregates can also contribute positively to the compressive strength of concrete to a certain extent.

The results show that the compressive strength of concrete is greatly influenced by the proportion and type of recycled aggregate used. The use of recycled aggregates, both coarse and fine, in the right proportions has the potential to produce concrete with competitive compressive strength. However, it should be noted that too high a proportion of recycled aggregates in concrete mixtures tends to lower their compressive strength. This confirms the importance of blended design optimization when utilizing recycled materials. Further research is needed to determine the optimal proportions of different types of recycled aggregates to suit a wide range of concrete applications. This research has provided valuable insights into the utilization of recycled concrete waste in the construction industry. This has great potential to improve sustainability and reduce the environmental impact of the construction sector in the future.

REFERENCES

[1] S. B. Ahmad, "Investigasi Pengaruh Air Laut Sebagai Air Pencampuran Dan Perawatan Terhadap Sifat Beton," *INTEK: Jurnal Penelitian*, vol. 5, no. 1, hlm. 48–52, 2018, doi: 10.31963/intek.v5i1.200.

[2] A. Umar, E. Budiman, dan F. Abdi, "Pengaruh Kuat Tekan Beton Dengan Menggunakan Semen BASF Masterflow 870 dan Limbah Beton Sebagai Pengganti Agregat Kasar," *Jurnal Ilmu Pengetahuan dan Teknologi Sipil*, vol. 4, no. 2, hlm. 1–7, 2020.

[3] E. S. Dewi, "Pemanfaatan Limbah Hasil Pengujian Beton Pada Proyek Bypas (BIL) Mandalika Sebagai Pengganti Sebagian Agregat Kasar Beton Normal," *Jurnal Ilmiah Teknik Sipil Fakultas Teknik*, vol. 2, no. 1, hlm. 1–8, 2023.

[4] A. R. M. Alifsyah, M. Jamal, dan T. S. P. Arifin, "Analisa Kuat Tekan Beton Menggunakan Metode Compression Test Dan Hammer Test Menggunakan Agregat Halus Pasir Tenggarong," *Teknologi Sipil : Jurnal Ilmu Pengetahuan dan Teknologi*, vol. 7, no. 1, hlm. 39, 2023, doi: 10.30872/ts.v7i1.11230.

[5] T. A. Liemawan dan I. G. P. Raka, "Pemanfaatan Limbah Kerang Hijau (Perna viridis L.) Sebagai Bahan Campuran Kadar Optimum Agregat Halus pada Beton Mix Design dengan Metode Substitusi," *Jurnal Teknik ITS*, vol. 4, no. 1, hlm. 128–133, 2015.

[6] B. Suhendro, "Toward green concrete for better sustainable environment," *Procedia Engineering*, vol. 95, hlm. 305–320, 2014, doi: 10.1016/j.proeng.2014.12.190.

[7] F. R. Putranto dan S. Syaiful, "Pengaruh Penambahan Genteng Press Jatiwangi Dan Damdex Terhadap Kuat Tekan Beton," *Jurnal Komposit*, vol. 3, no. 1, hlm. 15, 2019, doi: 10.32832/komposit.v3i1.3742.

[8] F. Zulkarnain dan L. Maulidza, "Pengujian Pengujian Kuat Tarik Belah Beton Dengan Abu Sekam Padi Sebagai Substitusi Parsial Semen," *DedikasiMU : Journal of Community Service*, vol. 6, no. 3, hlm. 337, 2024, doi: 10.30587/dedikasimu.v6i3.8287.

[9] R. Trimurtiningrum, "Pengaruh Pemanfaatan Abu Sekam Padi Terhadap Workabilitas, Resapan Dan Kekuatan Tekan Beton," *PAWON: Jurnal Arsitektur*, vol. V, hlm. 201–212, 2021.

[10] E. Poerwodihardjo dan I. Rustendi, "Analisis Pengaruh Penambahan Abu Sekam Padi Dan Superplasticizer (Consol Ss-8) Terhadap Kuat Tekan Beton Mutu Tinggi," *Teodolita: Media Komunkasi Ilmiah di Bidang Teknik*, vol. 22, no. 1, 2021, doi: 10.53810/jt.v22i1.393.

[11] B. S. N. Indonesia, "SNI 1974:2011, Cara uji kuat tekan beton silinder," 2011.

[12] B. S. N. Indonesia, "SNI 03-1969-2008, Metode pengujian berat jenis dan penyerapan air agregat kasar," 2008.

[13] B. S. N. Indonesia, "SNI 03-1970-2008, Metode pengujian berat jenis dan penyerapan air agregat halus," 2008.

[14] K. Suharwanto dan T. Taher, "Kuat Tekan Dan Tarik Beton Daur Ulang Yang Dibuat Dari Bongkaran Beton Perkerasan Kaku Jalan Sebagai Agregat Kasar: Studi Eksperimental," vol. 1, Nov 2020.

[15] B. S. N. Indonesia, "SNI 03-1968-1990, Metode pengujian analisis saringan agregat halus dan kasar," 1990.

[16] B. S. N. Indonesia, "SNI 03-1971-1990, Metode pengujian kadar air total agregat," 1990.

[17] N. Paryati, S. Nuryati, E. Yulius, dan A. M. Agussalim, "Analisis Hasil Kuat Tekan Beton Normal Terhadap Mix Design Kuat Tekan Beton Rencana," *Jurnal Kridatama Sains Dan Teknologi*, vol. 6, no. 02, hlm. 415–429, 2024, doi: 10.53863/kst.v6i02.1244.

[18] D. S. Devi, R. Nurmeyliandari, dan A. P. Pramadona, "Pengaruh Penggunaan Abu Sekam Padi dan Limbah Granit Terhadap Kuat Tekan Beton," *Borneo Engineering : Jurnal Teknik Sipil*, vol. 8, no. 1, hlm. 74–82, 2024, doi: 10.35334/be.v8i1.4976.

[19] B. S. Nasional, *SNI 1972:2011 - Cara uji slump beton*. Jakarta, 2011.

[20] H. Prayuda, "Kuat Tekan Beton Mutu Tinggi Menggunakan Komparasi," *Jurnal Riset Rekayasa Sipil*, hlm. 1–10, Sep 2018.

[21] S. Soelarso dan B. Baehaki, "Pengaruh Penggunaan Limbah Beton Sebagai Pengganti Agregat Kasar Pada Beton Normal Terhadap Kuat Tekan Dan Modulus Elastisitas," *Fondasi : Jurnal Teknik Sipil*, vol. 5, no. 2, 2016, doi: 10.36055/jft.v5i2.1254.