EISSN: 2622-6774
Vol 11 No.1 March 2024
http://cived.ppj.unp.ac.id/index.php/CIVED

Comparison of the Variation of Coarse Aggregate Gradation on the Strength of Concrete

Dwivan Dhama Laras[1*], Dadang Dwi Pranowo[2], Megalita Rodiyani[3], M. Shofi'ul Amin[4], Mohamad Galuh Khomari[5]
[1,2,3,4,5] Civil Engineering, Faculty of Engineering, Politeknik Negeri Banyuwangi, Indonesia
*Corresponding author, e-mail: dwivandhama20@gmail.com

Received 19th Feb 2024; Revision 8th March 2024; Accepted 20th March 2024

ABSTRACT

Concrete as the main construction material has an important role in determining the strength and reliability of a construction project. The quality of concrete is influenced by the properties of its constituent materials, such as gravel, sand, cement and water. Testing the compressive strength of concrete is an important step to assess its quality and ensure it meets construction standards. Although previous research has compared the compressive strength of concrete and changes in aggregate volume, this research still covers limited dimensional variations and further exploration of aggregate dimensional variations is needed. This laboratory study used a conventional concrete design according to SNI 03-2834-2000, with compressive strength tests carried out at the Material Testing Laboratory, part of the Civil Engineering Department at Politeknik Negeri Banyuwangi Banyuwangi. The experimental results recorded in the fourth chapter show that at 7, 14, and 28 days, type AG 10 has the highest compressive resistance value, statistically significant mean value, and also shows that type AG 40 has the lowest compressive strength value. Therefore, it can be concluded that the smaller the size variation of coarse aggregate, the higher the compressive strength of concrete. These findings provide a comprehensive picture of the compressive strength characteristics of concrete with varying coarse aggregate sizes.

Keywords: *Concrete; Coarse Aggregate; Compressive Strength; Size Variation; Material Testing Laboratory.*

INTRODUCTION

Concrete, as an important construction material, plays a crucial role in ensuring the strength and reliability of construction projects. The quality of concrete is greatly influenced by the properties of its constituent materials, especially coarse aggregates and fine aggregates such as gravel and sand, as well as cement and water. Testing the compressive strength of concrete is an important aspect in assessing its quality. These tests provide information about the strength of the concrete and indicate whether it meets the preset strength requirements for a particular construction application [17] [1].

Previous research has compared coarse aggregate sizes with 2 variations [2]. However, variations in coarse aggregate size have not been fully explored. Test results from previous studies have shown that smaller aggregate dimensions result in higher compressive strength [3]. However, these results cannot be considered as fully valid, and further research is needed to achieve optimal results in order to compare different coarse aggregate size variations on the compressive strength of concrete.

Coarse grains in concrete have several important functions. First, coarse grains provide mechanical strength to concrete. Second, coarse grains fill the voids in the concrete mix, reduce cement consumption, and improve the resistance of concrete to environmental influences and corrosion. Thirdly, suitable coarse grains can improve construction performance by affecting the rheology of concrete and being one of the ingredients for the concrete manufacturing process.

The size selection of coarse aggregate should also consider the size and shape of the mold, the method of placement, and the desired finish. Smaller coarse aggregate sizes are more suitable for smaller molds because they can fit tightly into the narrow gaps between molds and provide a surface area that has larger dimensions. However, the use of smaller aggregates can affect the strength and durability of the concrete. On the other hand, larger coarse aggregates can cause difficulties during casting and potentially cause defects in the final product.

Through an in-depth understanding of the function of coarse aggregates and their impact on the properties of concrete, the aim of this study is to present more detailed comprehensive information regarding the development of high-quality concrete and optimal performance for various construction applications.

METHODS

This is a laboratory experimental study, therefore it is important to know how the dimension of coarse aggregate particles in these concrete samples affects the compressive durability of standard concrete. The materials and production methods applied in this study are based on conventional concrete design in accordance with SNI 03-2834-2000. The methodology of this study includes laboratory experiments and testing of concrete with various sizes of coarse aggregate carried out at the Materials Testing Laboratory, part of the Civil Engineering Department at Politeknik Negeri Banyuwangi.

Mix Design

Mix design is the process of calculating the proportion of fillers in concrete mixtures to meet the desired strength and structural stability requirements. SNI 03-2834-2000 provides guidance in designing concrete mixtures using the SNI calculation method, which is usually used for the construction of buildings, bridges, and other infrastructure [6][1]. In this study, compressive strength comparisons were made with respect to changes in coarse aggregate size, namely 5-10 mm aggregate (AG 10), 10-20 mm aggregate (AG 20), and 30 to 40 mm aggregate. Aggregate size (AG 40).

Slump

Slump testing is a concrete consistency test conducted to verify that the concrete produced meets and exceeds the desired quality standards [6]. The following Table 1 shows the results of the slump test.

Tabel 1. *Slump* Testing Result

Aggregate Type	***Slump***
AG 10	12cm

AG 20	13cm
AG 40	14cm

It can be seen from Table 1 that the slump heights for each coarse aggregate size variation are as follows: AG 10 (aggregate size 5 to 10 mm) achieved a slump value of 11 cm; AG 20 (coarse aggregate 10 to 20 mm) achieved a slump height of 13 cm, and AG 40 (coarse aggregate 30 to 40 mm) achieved a slump value of 14 cm.

Test Item

Concrete compressive strength testing was conducted at 3, 7, and 28 days of concrete age. The concrete was tested in cylinders with dimensions of 150 mm x 300 mm, and the details are listed in Table 2 below:

Table 2: Results Showing the Number of Test Objects

Age (Days)	**Coarse Aggregate (mm)**			**Number of Test Objects (Piece)**
	Aggregate 5 – 10	**Aggregate 10 – 20**	**Aggregate 20 – 30**	
7	3	3	3	9
14	3	3	3	9
28	3	3	3	9
Total				27

Concrete compressive strength testing was carried out at various times, at 7, 14, 28 days respectively, with the aim of obtaining more complete information on the development of concrete compressive strength over time. The following are the reasons why at this stage, compressive strength testing of concrete is carried out:

1. Monitoring the early evolution of strength: Concrete compressive strength testing at 7 is useful for monitoring the early evolution of concrete compressive strength. At this early stage, concrete generally does not reach its planned maximum strength, but information on the early strength development can provide clues about the concrete's ultimate strength potential.
2. Average strength values: Testing after 14 days aims to evaluate the development of the average strength of the concrete. At this point, concrete usually reaches most of its design strength. Testing at this phase helps evaluate whether the concrete meets the set strength requirements and whether there may be a significant decrease or increase in strength.
3. Determination of final strength: The test after 28 days is the final test to determine the final strength of the concrete. At this point, the concrete should have reached or be close to the planned strength. The test results at this stage provide important information to evaluate whether the concrete meets the specified strength requirements and whether or not it can be safely used in construction projects.

Concrete compressive strength tests are conducted at various stages to observe the development and characteristics of concrete strength over time. This provides more comprehensive and accurate information on the quality and reliability of concrete at various stages. Therefore, testing at intervals of 7, 14, and 28 days provides a more in-depth understanding of the strength performance of concrete.

RESULTS AND DISCUSSION

CIVED Journal of Civil Engineering and Vocational Education
EISSN: 2622-6774
Vol 11 No.1 March 2024
http://cived.ppj.unp.ac.id/index.php/CIVED

After making samples of different sizes, compressive strength tests were conducted at 7, 14, and 28 days of concrete age.

Strength Testing Based on Age of Concrete Variation AG 10

Concrete strength tests for concrete variant AG 10 are shown in the following table and figure.

Table 3. Compressive strength test based on age of concrete Variant AG 10

Age	Concrete Weight (gr)	Max Load (kN)	Compressive Strength (MPa)	Average compressive strength (MPa)
7 Days	11.836	359.388	20.337	22.75
	11.738	431.152	24.398	
	11.692	415.539	23,515	
14 Days	11.712	523.224	29.608	27,35
	11.618	437.911	24.781	
	11.984	488.945	27.669	
28 Days	11.760	630.891	35.701	34.5
	11.916	613.799	34.734	
	11.756	587.401	33.240	

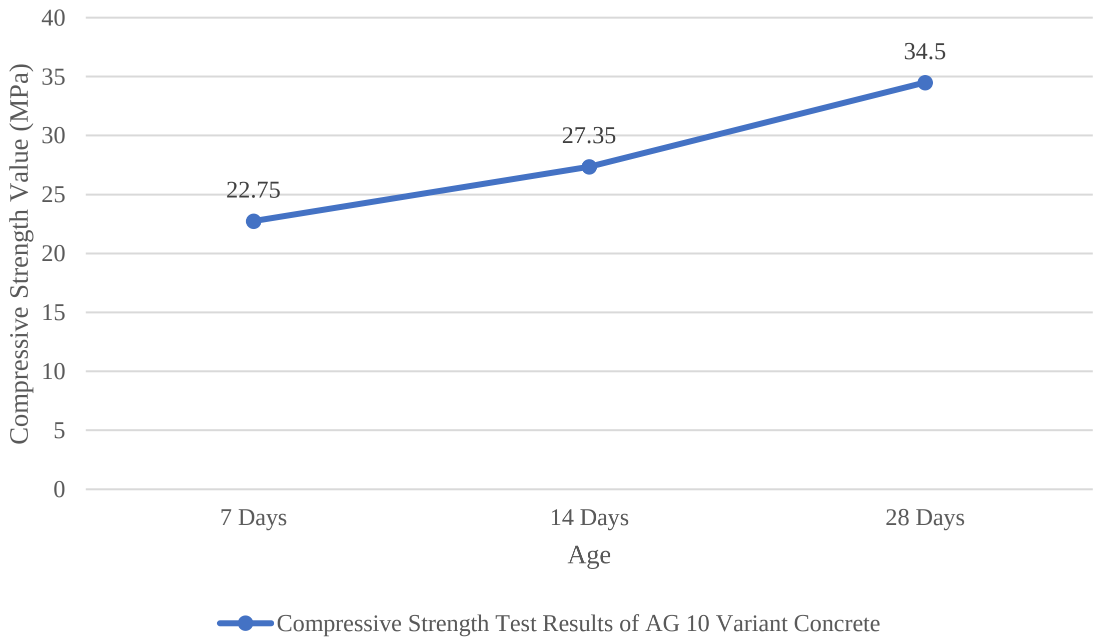

Figure 1. Compressive Strength Chart of AG 10 Variant Concrete

From Table 3, it can be concluded that the compressive strength values show that the 28-day age has the highest level of compressive strength, while the 7-day age has the lowest level of compressive strength. At the age of 7 days, the average value of compressive strength reached 22.75 MPa, while at the age of 14 days it reached 27.35 MPa, and at the age of 28 days it reached 34.5 MPa. These results are in accordance with the concrete compressive strength acceptance criteria based on the SNI 2847 standard: 2019, which clearly states that the final compressive strength result must be equal to or higher than the predetermined fc', which is 22.5 MPa. It can therefore be concluded that the age of the concrete greatly influences the

Journal of Civil Engineering and Vocational Education
EISSN: 2622-6774
Vol 11 No.1 March 2024
http://cived.ppj.unp.ac.id/index.php/CIVED

compressive strength figures. Figure 1 displays the compressive strength results for AG 10 variant concrete.

Strength Testing Based on Age of Concrete AG 20 Variation

Concrete strength tests for the AG 10 concrete variant are shown in the following Table and Figure.

Table 4. Compressive Strength Results by Age of Concrete AG 20 Variation

Age	Concrete Weight (gr)	Max Load (kN)	Compressive Strength (MPa)	Average compressive strength (MPa)
7 Days	11.812	210.186	11.894	19.29
	12.160	586.483	33.158	
	12.098	226.881	12.839	
14 Days	12.282	482.318	27.294	26.21
	12.290	469.670	26.578	
	12.100	437.780	24.773	
28 Days	12.070	633.182	35.831	33.35
	12.084	530.300	30.009	
	12.134	604.770	34.223	

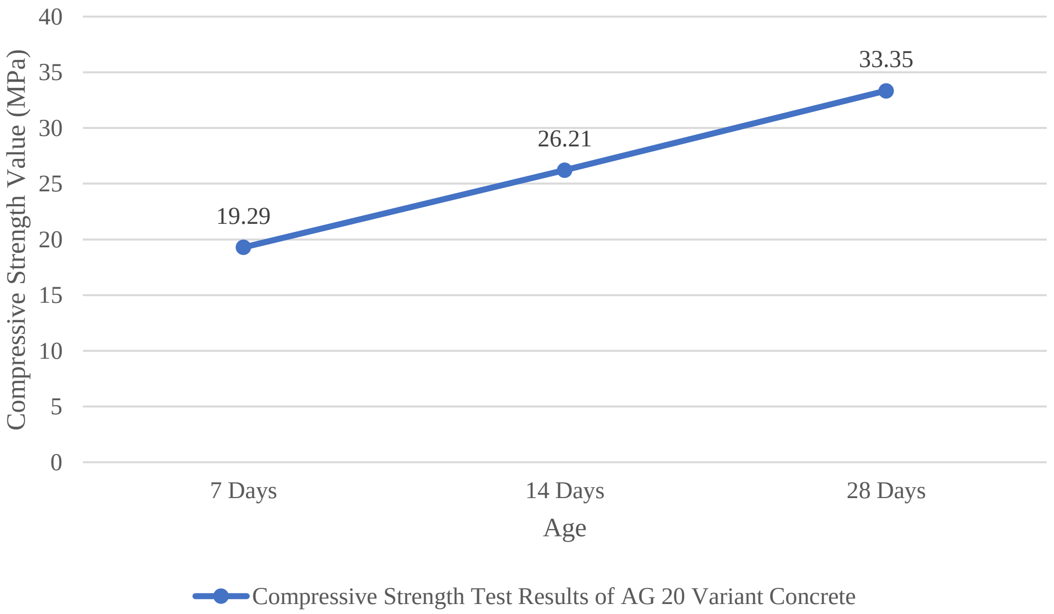

Figure 2. Compressive Strength Chart of Concrete Variant AG 20

From Table 3, it can be concluded that the compressive strength values show that the 28-day age has the highest level of compressive strength, while the 7-day age has the lowest level of compressive strength. At the age of 7 days, the average value of compressive strength reached 19.29 MPa, while at the age of 14 days it reached 26.21 MPa, and at the age of 28 days it reached 33.35 MPa. These results are in accordance with the concrete compressive strength acceptance criteria based on the SNI 2847 standard: 2019, which clearly states that the final compressive strength result must be equal to or higher than the predetermined fc', which is 22.5

MPa. It can therefore be concluded that the age of the concrete greatly influences the compressive strength figures. Figure 2 displays the compressive strength results for AG 10 variant concrete.

Strength Testing Based on Age of Concrete AG 40 Variation

Concrete strength tests for the AG 10 concrete variant are shown in the following Table and Figure.

Table 5. Compressive Strength Results Based on Age of Concrete Variation AG 40

Age	Concrete Weight (gr)	Max Load (kN)	Compressive Strength (MPa)	Average compressive strength (MPa)
7 Days	12.194	211.630	11.976	12.26
	12.132	276.890	15.669	
	11.822	161.749	9.153	
14 Days	12.438	402.921	22.801	20.9
	12.280	376.821	21.267	
	12.660	329.957	18.672	
28 Days	12.504	474.342	26.842	28.66
	12.208	535.936	30.328	
	12.426	509.520	28.833	

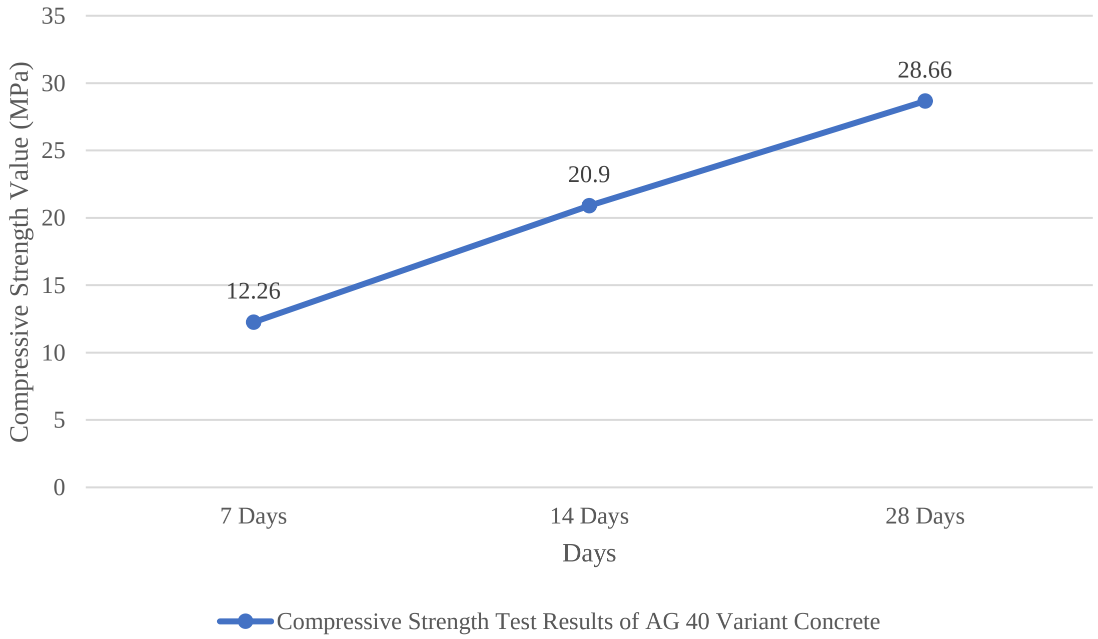

Figure 3. Compressive Strength Chart of AG 40 Variant Concrete

From Table 5, it can be concluded that the compressive strength value shows that the 28-day age has the highest level of compressive strength, while the 7-day age has the lowest level of compressive strength. At the age of 7 days, the average value of compressive strength reached 12.26 MPa, while at the age of 14 days it reached 20.9 MPa, and at the age of 28 days it reached 28.66 MPa. These results are in accordance with the concrete compressive strength acceptance criteria based on the SNI 2847 standard: 2019, which clearly states that the final compressive strength result must be equal to or higher than the predetermined fc', which is 22.5 MPa. It can

Journal of Civil Engineering and Vocational Education
EISSN: 2622-6774
Vol 11 No.1 March 2024
http://cived.ppj.unp.ac.id/index.php/CIVED

therefore be concluded that the age of the concrete greatly influences the compressive strength figures. Figure 3 displays the compressive strength results for concrete variant AG 10.

Strength Testing Based on Variation of Aggregate Gradation Size

Concrete strength tests based on aggregate size variants are shown in the following table and figure.

Table 6 Compressive Strength Results Based on Variation of Aggregate Size

Gradation	Concrete Weight (gr)	Max Load (kN)	Compressive Strength (MPa)	Average compressive strength (MPa)
AG 10	11.760	630.891	35.701	34.5
	11.916	613.799	34.734	
	11.756	587.401	33.240	
AG 20	12.070	633.182	35.831	33.35
	12.084	530.300	30.009	
	12.134	604.770	34.223	
AG 40	12.504	474.342	26.842	28.66
	12.208	535.936	30.328	
	12.426	509.520	28.833	

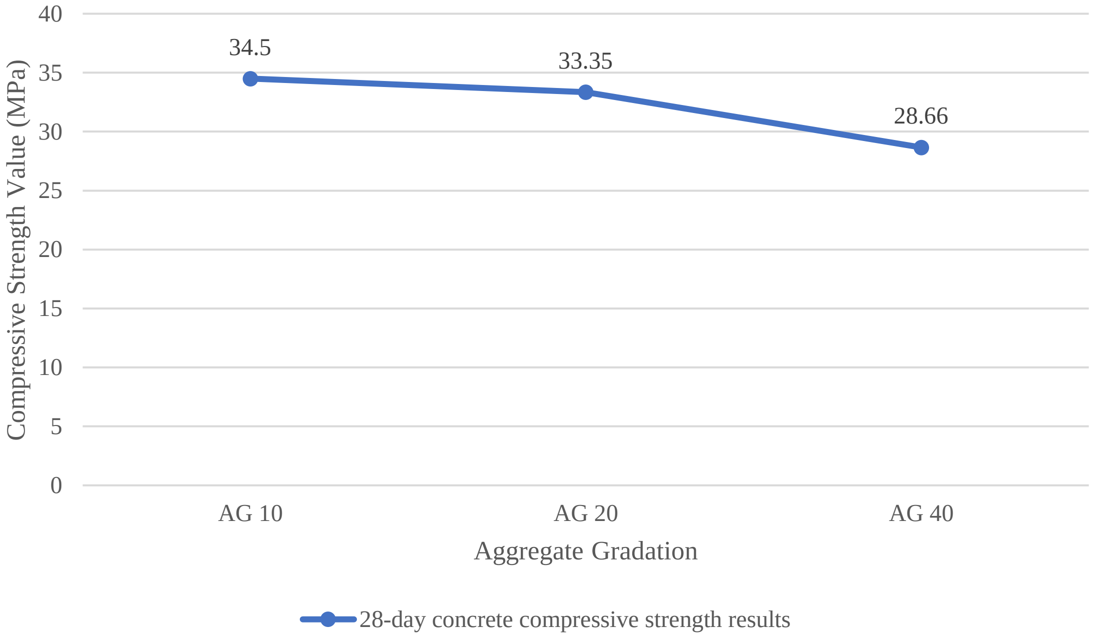

Figure 4. Compressive Strength Chart of 28-Day-old Concrete

From Table 6, it can be seen that the 28-day compressive strength test shows that size AG 10 has the highest value with an average 28-day compressive strength result of 34.5 MPa. AG 20 size has an average compressive strength of concrete at the age of 28 days reaching 33.35 MPa. Finally, size AG 40 has an average compressive strength of concrete at the age of 28 days reaching 28.66 MPa. With that, it shows compliance with the concrete compressive strength acceptance criteria based on SNI 2847: 2019 Which indicates that the final compressive strength results must be equal to or greater than the fc that has been set at the beginning, which is 22.5 MPa. Figure 4 displays the results of concrete compressive strength based on aggregate size variants.

CONCLUSIONS

Based on the analysis and testing of compressive strength of concrete with variant dimensions of coarse aggregate, the results obtained for AG 10 category, got an average strength of 22.75 MPa after 7 days, 27.35 MPa after 14 days, and finally 34.5 MPa after 28 days. For the AG 20 category, an average compressive strength of 19.297 MPa was obtained after 7 days, 26.21 MPa after 14 days, and 33.35 MPa after 28 days. For the AG 40 category, the average compressive strength was 18.8 MPa after 7 days, 23.7 MPa after 14 days, and 28.66 MPa after 28 days. This study showed that the highest strength was obtained for AG 10 coarse aggregate size, while the lowest compressive strength was obtained for AG 40 coarse aggregate size. Therefore, it can be concluded that, as the size of the coarse aggregate varies, its compressibility decreases, and the strength obtained tends to be low. On the contrary, as the size of coarse aggregate variation decreases, its compressibility increases, and the compressive strength of concrete obtained tends to increase.

REFERENSI

[1] Amin, M. Shofi'ul. 2019. Modul Laboratorium Uji Bahan Bangunan dan *Mix Design* Beton. Program Studi Diploma III (D3) Teknik Sipil Jurusan Teknik Sipil Politeknik Negeri Banyuwangi.

[2] Jurnal, R. T. 2018. Analisis Pengaruh Besar Butiran Agregat Kasar Terhadap Kuat Tekan Beton Normal: Ika Sulianti, Amiruddin, Rio Shaputra, Daryoko. In Forum Mekanika 7(1): 35-42.

[3] Manganta, M. 2018. Pengaruh Ukuran Butir Maksimum Agregat Kasar Terhadap Kuat Tekan Beton Mutu Tinggi. In Seminar Nasional Hasil Penelitian & Pengabdian Kepada Masyarakat (SNP2M). 2(1)

[4] Nasional, B. S. 1991. SNI-03-2493-1991 (Metode Pembuatan Dan Perawatan Benda Uji Beton Di Laboratorium). BSN, Jakarta.

[5] Nasional, B. S. 1998. SNI 03-4810-1998 Metode Pembuatan dan Perawatan Benda Uji Beton di Lapangan. Jakarta: Badan Standardisasi Nasional (BSNi).

[6] Nasional, B. S. 2000. SNI 03-2834-2000 Tata cara pembuatan rencana campuran beton normal. BSN, Jakarta.

[7] Nasional, B. S. 2002. SNI 03-2492-2002: Metode Pengambilan dan Pengujian Beton Inti. Jakarta: Badan Standardisasi Nasional.

[8] Nasional, B. S. 2002. SNI 03-2492-2002: Metode Pengambilan dan Pengujian Beton Inti. Jakarta: Badan Standardisasi Nasional.

[9] Nasional, B. S. 2004. SNI 15-2049-2004 Semen Portland. Jakarta: BSN.

[10] Nasional, B. S. 2013. SNI 2847: 2013 Persyaratan beton struktural untuk bangunan gedung. Jakarta: Dewan Standarisasi Indonesia.

[11] Nazir. 1998. Metode Penelitian. Jakarta: Ghalia Indonesia.

[12] Purwati, A. and Sunarmasto, S. 2014. Pengaruh Ukuran Butiran Agregat Terhadap Kuat Tekan Dan Modulus Elastisitas Beton Kinerja Tinggi Grade 80. Matriks Teknik Sipil, 2(2): 58-63. https://doi.org/10.20961/mateksi.v2i2.37436

[13] Sentana U.M.I. 2003. Pengaruh Ukuran Butiran Maksimum Agregat Kasar Batu Pecah dan Kerikil 20 mm Dan 40 mm terhadap Kuat Tekan Beton (Mengacu Pada SK- SNI, T-15-1990-03), Skripsi. Fakultas Teknik Universitas Mataram, Mataram.

[14] Sulianti, I. A. S. R. D. 2018. Analisis Pengaruh Besar Butiran Agregat Kasar Terhadap. Analisis Pengaruh Besar Butiran Agregat Kasar Terhadap, 7(1): 35-42.

[15] Sugiyono. 2018. Metode Penelitian Kualitatif Kuantitatif dan R&D. Jakarta: Alfabeta.

[16] UMl, S. 2003. Pengaruh Ukuran Butiran Maksimum Agregat Kasar Batu Pecah dan Kerikil 20 mm Dan 40 mm terhadap Kuat Tekan Beton (Mengacu Pada SK-SNI, T-15-1990-03).

[17] Zain, H. 2017. Pengaruh Variasi Diameter Maksimum Agregat Dalam Campuran Terhadap Kekuatan Tekan Beton. Jurnal Teknik Sipil Unaya, 3(1).