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Increasing Compressive Strength of Self Compacting Concrete with MasterGlenium and MasterSure

R. Sefiyanti[1*], Z. B. Mahardana[2], A. L. Rahmawati[3], N. Husna[4], Z. Zakiya[5], H. Naufalanto[6], T. B. Yuantono[7]

[1*,2,3,4,5,6,7]*Department of Civil Engineering, Faculty of Engineering, Kadiri University, Kediri, Indonesia*

Email: [1*] redykasefiyanti@gmail.com, [2] zmahardana@unik-kediri.ac.id, [3] aprthjk@gmail.com, [4] hnadiya533@gmail.com, [5] zaizafunzakiya30@gmail.com, [6] hafiznaufalanto@gmail.com, [7] tegarsosial@gmail.com.

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ABSTRACT

The growth in development complexity demands innovation in the construction industry. Self-compacting concrete (SCC) can flow and fill mold cavities without additional vibration, offering an efficient solution for structures with complex shapes or tight spaces. In addition, SCC can speed up bonding and simplify workability by adding MasterGlenium and MasterSure superplasticizers. However, its use is limited due to a lack of understanding of the optimal composition of the mixture. The research aims to determine the effect of adding MasterGlenium and Maste Sure in the concrete mixture on the compressive strength of concrete. Experimental research was conducted with a mixture of MasterGlenium additives at 0.25%, 0,30%, 0,35%, 0.40%, and MasterSure 0.30% of the total binder. Slump and compressive strength tests of concrete are carried out to determine workability and quality performance. The research results showed that the optimal concrete mix with the addition of MasterGlenium 0.35% and MasterSure 0.30% was 25.39 Mpa, higher than Normal concrete 15.21 Mpa. The slump test results confirm that the concrete is classified as SCC. This shows the importance of the composition of MasterGlenium and MasterSure superplasticizers on the compressive strength of SCC concrete. So, the results of this research can be used to improve the quality of concrete structure projects.

1. Introduction

Incessant construction of various structures such as houses, bridges, roads, and dams has caused demand for concrete to increase significantly, reaching 140 million tons in 2019 and

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is projected to continue to increase yearly [1], [2]. The compressive strength of concrete is one of the important requirements in construction because concrete is tasked with the load of its supports. The compressive strength of concrete is influenced by many factors, including mix proportions, design methods, concrete maintenance, and conditions during pouring [3]. Apart from that, the ease of working with concrete is also an important part of the construction industry today [4]. Concrete is a construction material made from a mixture of materials such as Portland cement, water, aggregate (sand, gravel, or crushed stone), and other additional materials such as additives or fillers. Concrete has advantages such as high strength, resistance to pressure, and fire resistance. However, concrete also has weaknesses if the mixture proportions are not correct, such as in cases where the Water Cement Factor (FAS) is too low, causing the concrete paste to be stirred and poured into the mold, causing the concrete to become porous so that the compressive strength value of the concrete becomes low. In contrast, high-quality concrete requires low FAS [5] [6].

Concrete work can be made easier without reducing the quality of the concrete and increasing its compressive strength by applying the Self-Compaction Concrete (SCC) concept. SCC is a type of concrete that can compact itself with high fluidity and workability so that it can flow and fill the spaces in the mold without a vibrator and can produce a homogeneous mixture with little or no air voids so it has high compressive strength [7]. SCC can be made by adding superplasticizer additives such as MasterGlenium and MasterSure [8]. MasterGlenium is a type of chemical that can improve the workability and quality of concrete [9]. Meanwhile, MasterSure functions as a FAS diluent, accelerating cement hydration without reducing the quality of the concrete [10] [11]. Using 1% superplasticizer of the MasterSure 1007 type increased the compressive strength of SCC concrete by 34.94 Mpa [12]. However, by adding 0.7% MasterGlenium type superplasticizer, the compressive strength decreased by 8.97 Mpa [13]. Several studies have revealed that concrete added with high doses of MasterGlenium superplasticizer can have low compressive strength and MasterSure with high doses has high compressive strength. However, discussions regarding variations in the complexity of additives and the optimal composition of MasterGlenium and MasterSure mixtures for the compressive strength of SCC concrete are still very limited.

The research aims to determine the effect of adding MasterGlenium and MasterSure in the concrete mixture on the compressive strength of concrete. The results that will be obtained are the slump value, which is used as a reference for the requirements for SCC concrete and the compressive strength value of the concrete to compare with normal concrete. Thus, the

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results of this research can be used as a reference in determining the ideal mix composition and contribute to the construction field in understanding the effect of MasterGlenium and MasterSure superplasticizer additives on the compressive strength of SCC concrete to improve the quality and structural performance of projects.

2. Research Method

This research was carried out experimentally in the laboratory using a method for making concrete test specimens with the Self Compacting Concrete (SCC) concept, which pays attention to the amount of use of MasterGlenium and MasterSure additives to achieve optimum compressive strength. Each sample used in the research was cylindrical in the form of 4 test objects with the names BT1, BT2, BT3, and BT4 with variations in the use of the MasterGlenium superplasticizer additive in the amount of 0.25%, 0.30%, 0.35%, and 0.40% and MasterSure in the amount of 0.30% of the weight of cement used. To fulfill the suitability of the constituent aggregates, it is necessary to test the coarse aggregate's mud content and abrasion test with a minimum wear value. The parameters used in testing concrete specimens were the slump flow test with the J-Ring and V-Funnel test equipment as a parameter for the homogeneity of the concrete paste, and the compressive strength test was carried out using a Compression Strength Machine.

2.1 Aggregate Feasibility

Aggregate functions as a filler in the concrete mixture, aggregate greatly influences the properties of the concrete and provides strength to the concrete, so the quality of the aggregate greatly influences the quality of the concrete produced. The selection and suitability of aggregate is an important part in making concrete. In this case, tests are carried out to obtain the suitability of aggregates in making concrete using the SCC concept.

2.1.1 Coarse Aggregate Testing

In making concrete, coarse aggregate is used in the form of crushed stone through a 10 mm sieve. Good coarse aggregate or gravel has a silt content of no more than 1% and a wear value of no more than 40% [14] [15]. Mud content testing is carried out using the coarse aggregate washing method with the specification of passing a 1.5 inch size sieve for 1 kg when dry. This research plans to use crushed stone aggregate with a wear value of no more than 30%.

2.1.2 Fine Aggregate Testing

The parameter for fine aggregate suitability is to conduct a mud content test. The fine aggregate used has a mud content of no more than 5%. The normal permitted mud content in

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fine aggregate is less than 5% of the total sand weight. The amount of mud content that exceeds the regulatory standards will affect the bond between the aggregate and cement paste [16] [17].

2.2 Material Requirements

The design of concrete material requirements is adjusted to the SNI 03-2834-2002 method where in its implementation a combination of SCC concrete making methods is carried out at the planned concrete compressive strength target of 21.7 Mpa. The planned material requirements used in the manufacture of concrete per m3 are as follows:

Table 1. Job Mix Formula Calculation.

Test Object	Coarse Aggregate	Fine Aggregate	Cement	MasterGlenium		MasterSure 0,3 %	Result
	(Kg)	(Kg)	(Kg)	(%)	(Kg)	(Kg)	(Kg)
N	5.484	3.610	3.907	-	-	-	13.00
BT1	5.484	3.610	3.885	0.25%	0.010	0.012	13.00
BT2	5.484	3.610	3.883	0.30%	0.012	0.012	13.00
BT3	5.484	3.610	3.881	0.35%	0.014	0.012	13.00
BT4	5.484	3.610	3.879	0.40%	0.016	0.012	13.00

Source: Analysis of Material Requirements Calculation (2023).

After the aggregate test is fulfilled, the job mix calculation is carried out to obtain the right proportion of materials to achieve the expected compressive strength. So that each sample obtained to identify as concrete compressive strength compares SCC concrete and normal concrete (N). The sample used for the test was a cylinder-shaped mold with a diameter of 15 cm and a height of 30 cm. The total weight of the test object in 1 concrete cylinder is 13 kg.

2.3 Slump Test

The slump test aims to determine the workability of concrete. The slump test is planned using the Self Compaction Concrete concept according to the method. The slump test uses J-Ring and V-Funnel tools. The provision of J-Ring with SCC concrete must pass through a diameter of 50 cm within 2 - 5 seconds. The V-Funnel is used to measure the degree of dilution. If there is too much coarse aggregate, the flow ability will be slower, so additives need to be added [18]. The V-Funnel requirement for SCC concrete should be less than 8 seconds.

2.4 Concrete Compressive Strength

The compressive strength test is conducted to determine the strength of the concrete to withstand the load according to the needs of the planned structure. The concrete compressive strength test is carried out when the concrete reaches the age of 7 days. The tool used is the Universal Testing Machine [19]. Concrete is given a load until it is destroyed, when the maximum load acts.

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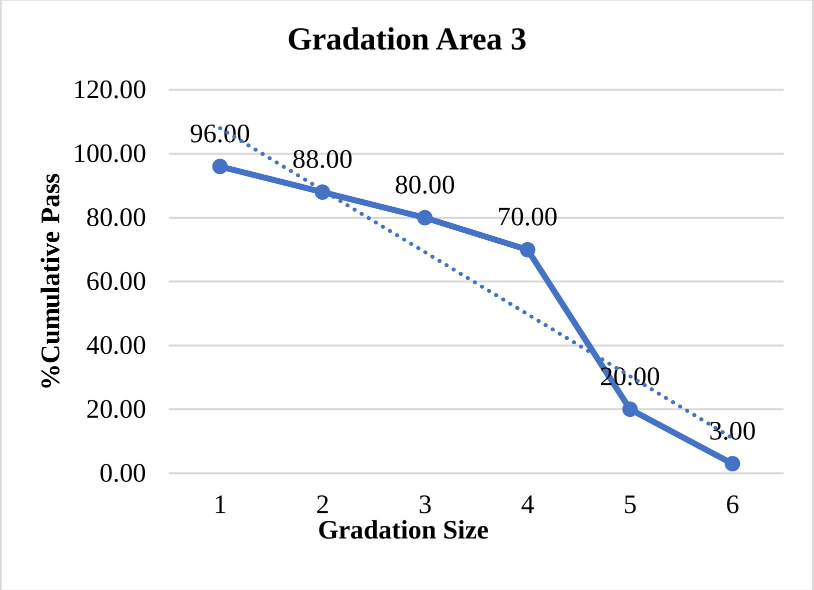
3. Results and Discussions

3.1 Aggregates Feasibility



Source: Aggregate Feasibility Calculation Results (2023).

Figure 1. Graph of Sieve Gradation Test Results.

From the sieve gradation test, the classification into region 3 is obtained, it can be concluded that the fine aggregate used in the concrete mixture is dominated by fairly fine particles. From the calculation chart of SNI 03-2834-2000, it shows the percentage of fine aggregate material requirement in the combined aggregate of 39.7% and coarse aggregate of 60.3%.

The mud content test results for fine aggregate were 1.65%, this percentage meets the clean standard limit for mud content specifications, namely <5%. The mud content in coarse aggregate is only 0.6%, this meets the specified requirements, the lower the mud content, the higher the compressive strength of the concrete. At 1% mud content, the compressive strength of concrete reaches 36.68%. In addition, the coarse aggregate wear value was obtained at 24.4%, also meeting the specified specification standards, namely not exceeding 40%. This indicates that the concrete mixture will have good resistance to abrasion and friction during use, as well as an optimal service life.

3.2 Slump Test

In the slump test, the equipment used is J-Ring Tester and V-Funnel with the results obtained as follows:

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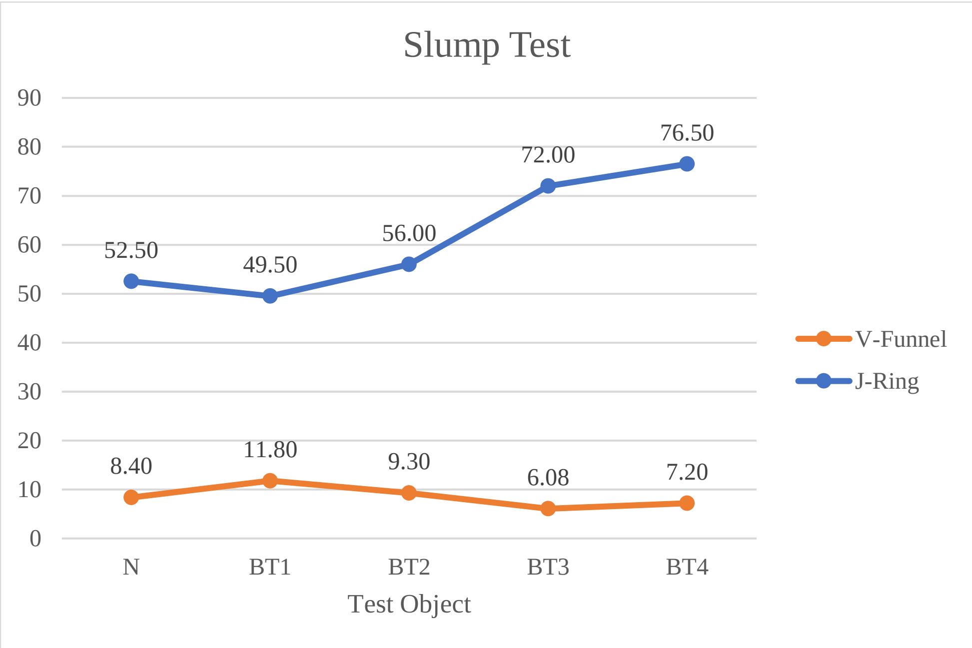
Table 2. Test Results of Slump Test.

Test Object	J - Ring				V - Funnel	
	D1	D2	Flow	SCC	T	Viscosity
		Cm			(s)	
N	50.00	55.00	52.50	SCC Compliant	8.4	VF 1 good filing
BT1	49.00	50.00	49.50	Not Compliant	11.8	VF 2 bad filling
BT2	55.00	57.00	56.00	SCC Compliant	9.3	VF 2 bad filling
BT3	69.00	75.00	72.00	SCC Compliant	6.08	VF 1 good filing
BT4	77.00	76.00	76.50	SCC Compliant	7.2	VF 1 good filing

Source: Slump Test Calculation Results (2023).



Source: Slump Test Calculation Results (2023).

Figure 2. Graph of Slump Test Results.

In the J-Ring test, the BT1 test specimen did not meet the SCC criteria because the flow value was less than 50 cm, and in the V-Funnel test the resulting viscosity was VF 2 (bad filing) because the duration exceeded 8s**.** This indicates that the concrete paste has insufficient viscosity to fill the cracks and empty spaces in the concrete mix properly. Therefore, adjustments to the material proportions or the use of additives were made to improve the flow and filling of the concrete [20].

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Source: Research Results (2023).

Figure 3. BT3 Slump Test using J-Ring.

Source: Research Results (2023).

Figure 4. BT3 Slump Test Time Duration.

The test results of J-Ring BT3 supplemented with MasterGlenium 0.35% and MasterSure 0.30% are shown in **Table 2.** and **Figure 4.** it takes 4.33 seconds to reach D50. This shows that in the J-Ring test the concrete mix is considered to meet the properties of SCC concrete.

Source: Research Results (2023).

Figure 5. BT3 Slump Test using V-Funnel

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Source: Research Results (2023).

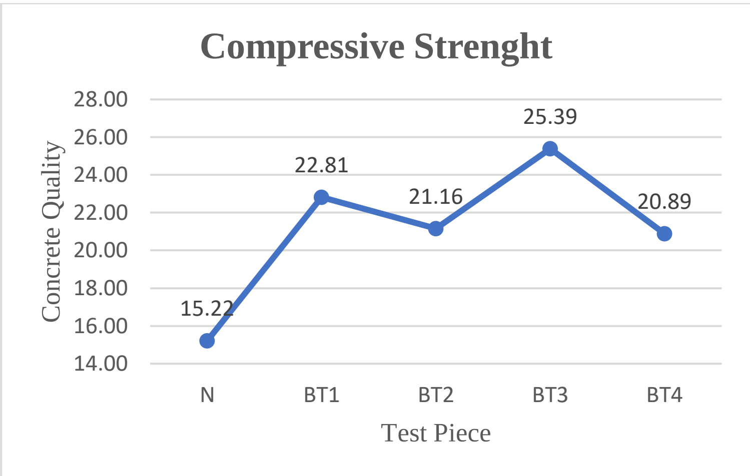
Figure 6. BT3 V-Funnel Time Duration

The test results of V-Funnel BT3 supplemented with MasterGlenium 0.35% and MasterSure 0.30% are shown in **Table 2.** and **Figure 6.** show that the concrete paste can flow to fill the space only requiring 6.08 seconds to pass through the mold gap, so it is included in the viscosity of VF 1 (good filing). This ensured optimal contact between the aggregate particles, which improved the concrete mix's ability to achieve optimal density when cast [21].

The test results for fine aggregate material showed a value of 1.65%, which could increase the slump value of fresh concrete which could later indicate the potential for developing an SCC mixture. On the other hand, the influence of the suitability of coarse aggregate material of 0.6% on the slump value is minimal, indicating a more fluid concrete consistency. However, coarse aggregate that experiences wear of 24.4% tends to have a rough surface, which can interfere with the concrete's ability to flow properly and negatively affect the slump test value which in turn disrupts the SCC consistency.

3.3 Concrete Compressive Strength

The results of the concrete compression test consisting of 5 samples using the Universal Testing Machine as a concrete testing tool, which underwent a concrete curing period of 7 days, showed the following results:



Source: Research Results (2023).

Figure 7. Graph of Concrete Compressive Strength Test Results.

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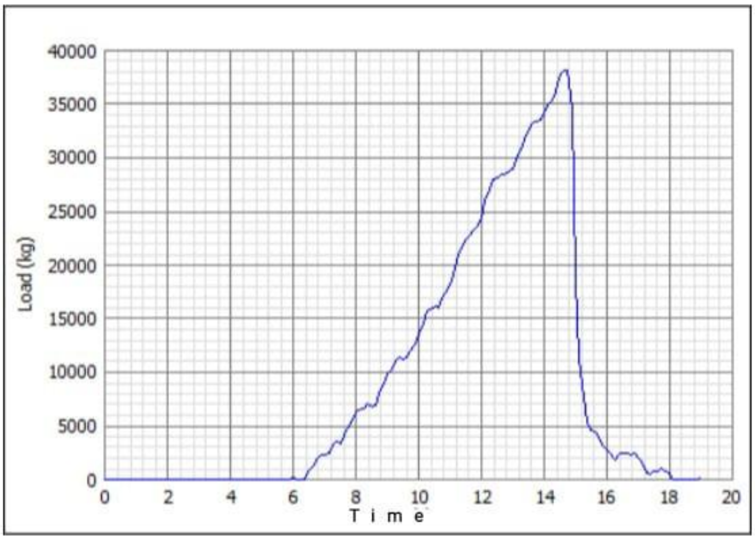
The average compressive strength value obtained for concrete with the addition of MasterGlenium 0.25% and MasterSure 0.30% experienced an increase of 50% from the compressive strength of normal concrete. With the addition of MasterGlenium 0.35% and MasterSure 0.30%, the compressive strength increased by 66%, reaching 25.39 Mpa. Meanwhile, the achievement of concrete strength with the addition of 0.30% and 0.40% additives tends to decrease compared to the strength achieved previously, namely the addition of 0.35% additives. This is due to the addition of MasterGlenium in different proportions, so that the additive content with the appropriate percentage will have a greater effect on the cement water factor value and will also have an effect on reducing the homogeneity of the concrete mix [22] [23]. Previous research has shown that the use of the MasterGlenium additive in making concrete can increase the compressive strength of concrete in accordance with the target set, as proven by the use of a combination of 0.30% MasterGlenium additive, the compressive strength of the concrete reached an average of 15.52 Mpa, exceeding the planned target of 15.00 Mpa [24].



Source: Research Results (2023).

Figure 8. BT3, Sample 3 Compressive Strength Test Graph

In **Figure 8**. the highest concrete compressive strength results were obtained for test object BT3 sample 3 with a compressive load of 38128.170 kg of 32.84 Mpa. This is influenced by the relatively low slump value, namely 6, so that the concrete produces high compressive strength. It can also be explained that the slump value greatly influences the compressive strength obtained [25] [26]. Thus, adding water to the mixture will affect the slump value and compressive strength.

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4. Conclusions

The research results show that concrete with the SCC concept on BT3 specimens using MasterGlenium 0.35% and MasterSure 0.30% additives has achieved an optimum compressive strength of 25.39 Mpa, higher than Normal concrete of 15.21 Mpa. The implications of the results of this research can have an impact on construction practice, where the use of SCC concrete with appropriate additives can improve the quality and structural performance of projects. Thus, this research significantly contributes to understanding the effect of MasterGlenium and MasterSure superplasticizer additives on the compressive strength of SCC concrete.

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