Effect of Cockle Shell Powder on The Compressive Strength of Concrete with Viscocrete 3115 N Additive

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ABSTRACT

The use of concrete as a building construction material is widely recognized for its high compressive strength and corrosion resistance. Concrete is a material that consists of a mixture of cement, fine aggregate, coarse aggregate, and water. Aggregates are mineral grains that serve as fillers in concrete mixtures. Cockle shell powder are a type of waste used as a substitute for fine aggregate because they can be used to increase the compressive strength of concrete. Sika Viscocrete 3115 N improves concrete properties, such as strength and durability and reduces water usage. This study analyzed the effect of using cockle shell powder as a substitute for fine aggregate at 5%, 10%, and 15%, and using Sika Viscocrete 3115 N as an additive to cement at 0.8%. Based on the results of the compressive strength test, it shows that normal concrete at the age of 28 days is 25.39 MPa, 0.8% SP concrete at the age of 28 days is 25.85 MPa, while concrete with fine aggregate substitution in the form of cockle shell powder at 5% at the age of 28 days is 26.12 MPa, 10% substitution is 31.75 MPa, and 15% substitution is 35.45 MPa. The use of 0.8% SP effectively increases the compressive strength of concrete from normal concrete, while the higher the use of cockle shell powder as a substitute for normal concrete.

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1. INTRODUCTION

The use of concrete as one of the materials forming building construction at this time has been widely recognized compared to other building materials. The use of concrete has several advantages, namely, high compressive strength and properties resistant to corrosion or attack against environmental conditions. In general, concrete forming materials are a mixture of binding materials such as cement, filler materials consisting of fine aggregate, coarse aggregate, and water to make it easier to mix the solid concrete ingredients [1]. Concrete is a building material with relatively better fire resistance than other construction materials. Concrete also has low thermal conductivity. Aggregates are mineral grains that function as fillers in concrete mixtures. Aggregates are obtained from natural resources that have undergone natural size reduction. One way to encourage sustainable construction is to practice resource-saving alternative concrete forming materials. The use of natural resources can be replaced with recycled materials as construction materials which are relatively cheaper than waste [2]. Use of sand or fine aggregate in concrete constituent materials continue to increase, resulting in many hills are being eroded and reduce natural resources. Utilization of shells effectively used as fine aggregate in mixtures concrete so that it can reduce usage excessive sand [3]. In recent years, issues related to shellfish waste have come to the attention of research as this can promote development progress [4].

Several studies have been carried out to use alternative new materials in making concrete in order to improve the characteristics of the resulting concrete. The use of waste as a utilization of construction materials continues to be pursued in determining the concrete's characteristics and economic value, the use of cockle shells. Cockle shell powder is a type of food waste that has been researched to be used to improve the properties of concrete[5]. The use of turtle shell waste has economic value because it has a hard texture and contains pozzolanic chemical compounds, namely lime (CaO), aluminum oxide, and silica, so it can affect the compressive strength of concrete [6] The percentage of using shells of 5% resulted in an increase in the compressive strength of concrete at 28 days of 6.24 MPa compared to concrete without shells [7]. The use of 5% shellfish powder substitution can be increased resistance to chemical attack [8]. A percentage of shells of 10% has been studied to improve the properties of mortar, reduce water absorption and increase compressive strength. Using too much shell powder can be avoided because it can reduce the compressive strength of the concrete [9]. Concrete mix that uses cockle shells as a partial replacement for fine aggregate as much as 15% can increase concrete characteristics such as concrete density [10]. This increase is due to the powder's sand-like shape.

One of the additives that can be used in concrete mixes is superplasticizer Sika Viscocrete 3115 N is a sperplasticizer useful for improving concrete properties, such as strength, durability and reducing water usage. Sika Viscocrete 3115 N used in a concrete mix of 2% produces a concrete compressive strength at 28 days of 51.5 MPa, which means there is an increase in concrete quality from the planned 42 MPa [11]. This shows that using Sika Viscocrete 3115 N eeffectively increases the compressive strength of concrete. Therefore, this research aims to determine the concrete slump value, concrete setting time and concrete compressive strength using Sika Viscocrete 3115 N with the use of cockle powder as a substitute for fine aggregate.

1.1. Cockle Shell Powder

The use of cockle shell as a concrete mixture has been widely used. This is due to the fairly high CaO content in the shells. Cockle shell powder has a very high calcium content. Cockle shell powder contains calcium carbonates thus provide high strength to the shell structure, low mass and low thermal coefficient power [12]. Various types of shellfish such as blood clams, green clams, oyster shells, bamboo shells are used as a substitute for sand, coarse aggregate, and as a substitute for cement [13]. Cockle shells are a type of shellfish that people in East and Southeast Asia commonly eat. Members of the Arcidae tribe call blood clams because these clams produce hemoglobin in the form of a red liquid. These clams inhabit the Indo-Pacific region and are spread from the coast of East Africa to Polynesia. This animal likes to bury itself in sand or mud. Its adult size is around 5 to 6 cm in length and 4 to 5 cm in width.

Cockle shells (Anadara Granosa) has chemical content in CaO 67.02%, SiO_2 8.252%, Mg_2O 22.652%, Al_2O3 1.622%, Fe_2O 0.402% [7]. The chemical content of cockle shells is similar to the chemical content of cement, especially CaO, which is the main constituent of cement and determines cement's strength. Research related to the use of shellfish such as cockle clams has been studied which can be used as a coarse aggregate of 20-30% and 20-50% as a fine aggregate. Apart from that, the use of 20% shellfish powder in concrete has the ability to increase the rate of cement hydration and the strength of the concrete [14].

1.2. Sika Viscocrete 3115-N

Sika Viscocrete is an additive that functions as a Super Power Plasticizer that can theoretically produce high quality concrete and as a Water Reducer that can reduce water usage by up to 40% when compared to the manufacture of ordinary concrete [15]. Sika viscocrete 3115-N is the latest generation of added materials for concrete and mortar. This type of additive is used specifically to produce concrete with high flow ability and reduces large amounts of water usage. Sika viscocrete 3115-N can be used for the following types of concrete:

1. Concrete with high flow ability and has concrete with high quality values.
2. Self-compacting concrete (SCC)
3. Concrete with very high water reduction requirements (up to 30%)

To obtain optimal benefits from large amounts of water reduction, wet mixing for a minimum of 60 seconds is recommended. Adding the remaining amount of water (to obtain a good concrete consistency) can only be started after 2/3 of the mixing time in wet conditions to avoid excessive amounts of water in the concrete. Concrete produced with Sika Viscocrete 3115-N exhibits the following properties:
a. Excellent flowability (results in a high reduction of placement and compaction efforts)
b. Self-compact capability is strong
c. Very high water reduction (shown in the density and strength of the concrete) and reduced cracking and shrinkage

1.3. Concrete Constituent Materials

The following are the concrete mixtures used:

1. Cement
   Cement is a chemical that hardens other mixed materials into a rigid and durable form.

2. Coarse aggregate
   Coarse aggregate can be gravel, crushed gravel, crushed stone, granite or crushed hydraulic cement concrete. Aggregate is a natural product that has a wide variety of qualities and gradations, therefore, in order to be used as a concrete forming material, aggregate must meet the requirements set out in a concrete mix design standard [16].

3. Fine aggregate
   Fine aggregate is a filler in the form of sand. The size of the fine aggregate varies, namely ASTM standard sieve no. 4 and no. 100. Fine aggregate to be used in the concrete mixture must be free from organic materials or other materials that can damage the concrete mixture. Size variations in a mix must have good gradation, following the sieve analysis standards of ASTM (American Society of Testing and Materials).

4. Water

Water is needed for the cement reaction to continue (without water, cement cannot react to harden) and can act as a lubricant between the aggregate grains so that the concrete mixture is easy to work with and compact. Water must be free from acid-base substances and oil.

5. Admixture
   Admixture is a chemical or natural mineral added to the concrete mixture. Additives are used to change the characteristics of concrete, such as increasing workability without adding water, accelerating hardening, and increasing compressive strength, or for other purposes such as saving energy.

1.4. Concrete constituent materials

The compressive strength is the maximum capacity of a material to withstand load per unit area. The strength of concrete is affected by water cement ratio, type of aggregate, workability, curring, and age of concrete. To obtain concrete with the desired strength, concrete needs to be properly treated at an early age, so that the hydration process runs perfectly. Based on SNI 03-1974-1990, the compressive strength of concrete is the amount of load per unit area that causes the concrete test object to crumble when loaded with a certain force produced by a press machine. Concrete properties are generally better if the compressive strength is higher, thus to review the quality of concrete is usually done by reviewing its compressive strength. The compressive strength of concrete is the ratio between the load to the cross-sectional area of the concrete [5]. The equation used to determine the compressive strength value of concrete based on (SNI 1974, 2011) as follows:

$$fc' = \frac{P}{A} \tag{1}$$

Where :
fc' = Compressive Strength of Concrete (Mpa or N/mm^2).
P = Crushing load (N)
A = Area of cylinder (mm^2)

2. RESEARCH METHODS

The process where research begins from previous research as a basis for preparing the final project to obtain relevant and up-to-date information about research obtained from journals and scientific writings. Then the preparation of materials and tools needed in accordance with testing standards and the mixture of mateial according to the composition design. The method used is direct testing in the laboratory. Tests are carried out on fresh concrete such as slump test, setting time. After the concrete has hardened, a concrete compressive strength test is carried out and to determine the effect of the substitution of a mixture of cockle shell powder as a substitute for fine aggregate on the compressive strength of the concrete using Viscocrete 3115 N with a substitution of 5%, 10%, 15% for shell powder for 28 days and the addition of viscocrete 3115 N as much as 0.8%.

3. RESULTS AND DISCUSSION

3.1. Material Testing

Several tests were carried out on the material, the added material in the form of cockle shell powder as a substitute for fine aggregate. Testing is carried out as a comparison of the results of the data that has been tested with the requirements specified in SNI. The following material testing can be seen in the table 1 and table 3.

Table 1. Fine Aggregate Testing Results

Testing Type	Berat/m³
Sieve Analysis	Zona 3
Specific Gravity	2,37
Water Content (%)	1,26
Mud Content (%)	2,36
Absorption (%)	1,28
Fineness Modulus (FM)	2,21

The results of the fine aggregate obtained a fineness modulus for the fine aggregate of 2.21, which means it can be concluded that the FM value of this fine aggregate meets the specified requirements. Apart from that, the fine aggregate used is included in gradation zone 3, which means that the fine aggregate has quite fine grain fineness.

Table 2. Coarse Aggregate Testing Results

Jenis Pengujian	Berat/m³
Sieve Analysis	1/2
Specific Gravity	2,65
Water Content (%)	1,09
Mud Content (%)	0,46
Absorption (%)	0,54
Fineness Modulus (FM)	6,01

In addition, the coarse aggregate used is included in the maximum size of coarse aggregate of 40 mm and can be used in the manufacture of concrete.

Table 3. Testing results of cockle shell powder

Jenis Pengujian	Berat/m³
Sieve Analysis	Zona 3
Specific Gravity	1,83
Water Content (%)	1,17
Absorption (%)	1,87
Fineness Modulus	2,01

Based on the results of Table 3, it is found that the testing of cockle shell powder has met the predetermined requirements, besides that the cockle shell powder is included in zone 3, which means that the cockle shell powder has a level of fineness that is quite smooth and can be used in making concrete.

3.2. *Slump Test*

Slump Test is conducted to measure the consistency level of the concrete mixture made before use. the *slump test* value used in this study is 12 ± 2 cm.

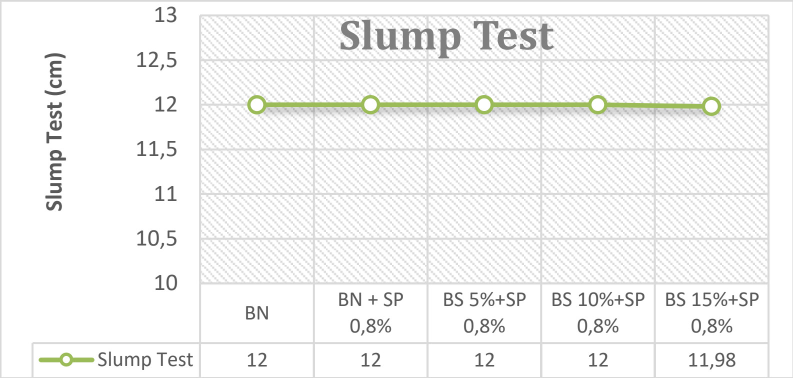

Figure 1. Slump Test Results

Based on Figure 1 shows that the *slump test* for normal concrete is 12 cm, 0.8% SP concrete is 12 cm, 5% substitution is 12 cm, 10% substitution is 12 cm and 15% substitution is 11.98 cm. From all the results of the Slump Test of normal concrete SP 0.8% and concrete variations of cockle shell powder all enter the planned slump of 12 ± 2 cm and the use of higher shell powder or at a percentage of 15% produces the lowest slump value which indicates that concrete with fine aggregate substitution in the form of cockle shell powder 15% has a higher concrete density.

3.3. *Setting Time*

The *setting time* test aims to determine the initial and final setting time of the concrete. The *setting time* test is carried out on concrete in a fresh condition until it hardens.

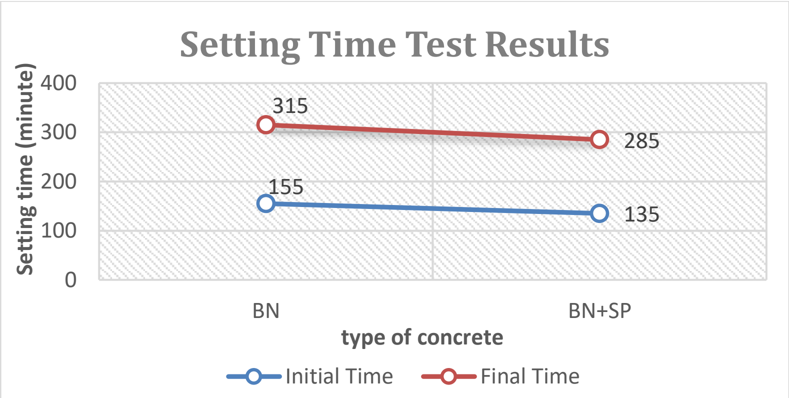

Figure 2. Setting Time Test Results

Based on Figure 2, it shows that the setting time test on normal concrete without superplasticizer additives produces an initial binding time of 155 minutes and a final binding time of 315 minutes, while for concrete using SP 0,8% the binding time is 135 minutes and the final binding time is 285 minutes. This shows that concrete using SP 0,8% is effective to accelerate the final binding time of concrete by 30%.

3.4. Compressive Strength Test Results

The next stage is testing the compressive strength of the concrete for concrete ages of 7, 14, 28 days. This test was carried out to find out how the use of cockle shell powder affects the strength of concrete and a comparison was made with concrete without using cockle shell powder.

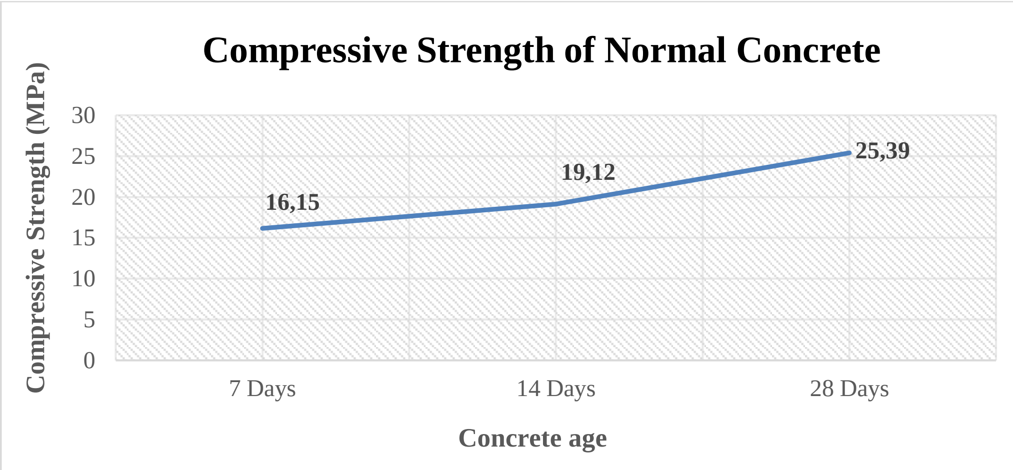

Figure 3. Compressive Strength test results of normal concrete

Based on the results of Figure 3. Testing can be seen that the average compressive strength value of normal concrete at the age of 7 days is 16.5 MPa, 14 days of concrete age is 19.12 MPa and 28 days of concrete age is 25.39 MPa. So it can be concluded that the compressive strength of concrete increased by 2.62 MPa on days 7 and 14 and on days 14 to 28 it also increased by 6.27 MPa. This can happen because as the age of concrete increases, it will reach 100% compressive strength of concrete at the age of 28 days.

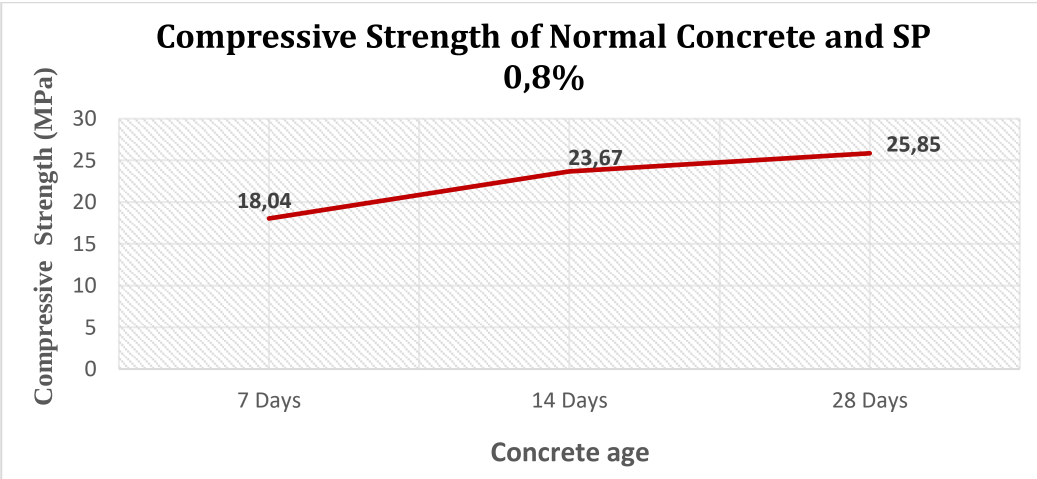

Figure 4. Compressive Strength test results of normal concrete and SP 0,8%

Based on the results of Figure 4. it can be seen that the compressive strength value of normal concrete + SP 0,8% at the age of 7 days is 18.04 MPa, 14 days of concrete age is 23.67 MPa and 28 days of concrete age is 25.85 MPa. So it can be concluded that the compressive strength of concrete increased by 5.63 MPa on days 7 and 14 and on days 14 to 28 also increased by 2.18 MPa. When compared with normal concrete, concrete with 0.8% SP additive can produce a concrete compressive strength of 25.85 MPa at the age of 28 days.

The following documentation of the results of the concrete compressive strength test and concrete crack patterns is shown in Figure 5 and Figure 6.

Figure 5. Crack pattern of 5% cockle shell powder specimen

Figure 6. Crack pattern of 15% cockle shell powder specimen

The difference in crack patterns can occur due to the inhomogeneous distribution of coarse aggregate and fine aggregate in the concrete mix so that cracks occur at points that lack aggregate. The second difference in crack patterns can occur due to segregation of concrete materials during the manufacture of test specimens. The heavier material will be at the bottom and the lighter material will be at the top, causing porous concrete. Both of these are strongly influenced by human factors in the concrete manufacturing process [17]. In general, the cracks that occur in each specimen mostly have the same pattern with the more composition of cockle shell powder, the smaller the impact of cracks that can be seen. The cracks that occur in the 5% and 15% cockle shell powder specimens are classified as cone and shear destruction patterns. The ideal crack pattern is expected to be cone-shaped. Because the cone-shaped crack pattern shows the density of the cylindrical specimen is evenly distributed and the surface is flat, so that the spread of pressure during compressive strength testing occurs evenly over the entire surface which is then distributed evenly over all parts of the cylinder [18]. The use of more cockle shell powder can fill the density in concrete and reduce cracks that occur due to compressive loads.

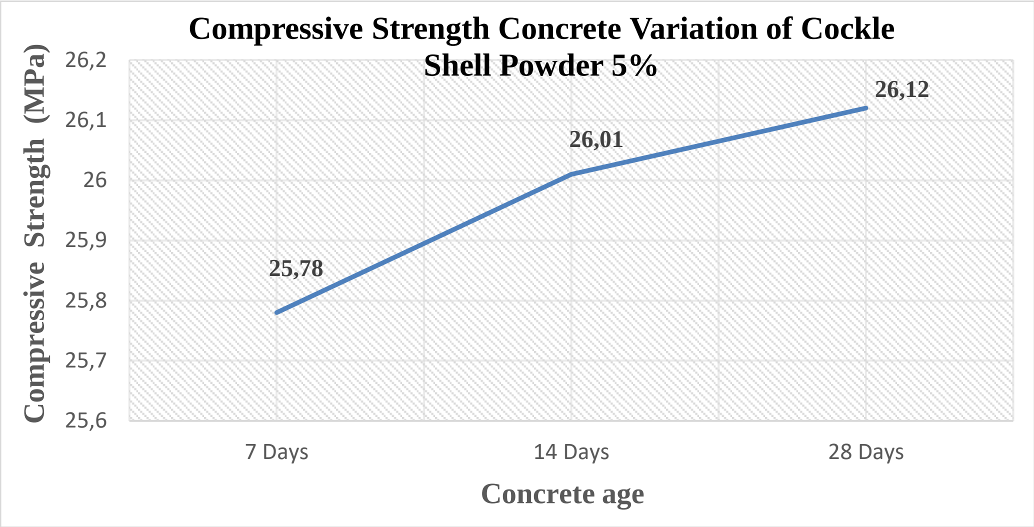

Figure 7. Compressive strength results of 5% cockle shell powder + 0.8% SP

Based on Figure 7. it is obtained that the results of concrete with a substitution of cockle shell powder + SP 0,8% variation of 5% at the age of 7 days of concrete amounted to 25.78 MPa, for 14 days of concrete amounted to 26.01 MPa and 28 days of concrete age amounted to 26.12 MPa. So based on the graph above, it can be seen that the compressive strength of concrete has increased by 0.23 MPa on days 7 and 14 and on days 14 and 28 it has also increased by 0.11 MPa. This can happen because as the age of the concrete increases, it will produce concrete compressive strength and reach 100% compressive strength at 28 days.

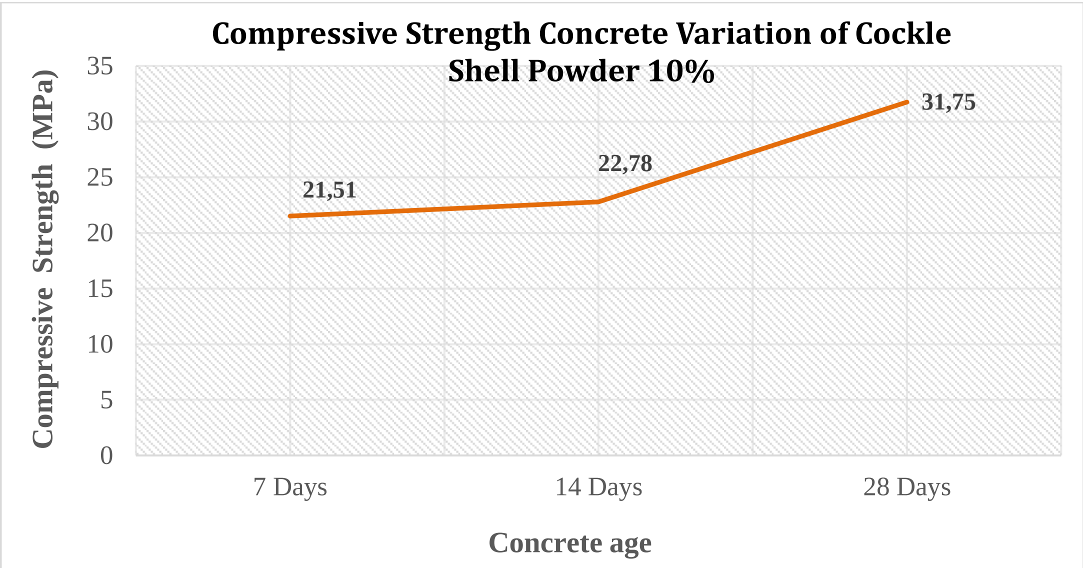

Figure 8. Compressive strength results of 10% cockle shell powder + 0.8% SP

Based on Figure 8. shows the results of concrete with variations of cockle shell powder 10% + SP 0,8% substitution at the age of 7 days of concrete of 21.51 MPa, for 14 days of concrete of 22.78 MPa and 28 days of concrete age of 31.75 MPa. So it be based on the graph above, it can be seen that the compressive strength of concrete has increased by 1.27 MPa on days 7 and 14 and on days

14 and 28 it also increased by 8.97 MPa. The increase in compressive strength occurs because as the age of the concrete increases, the compressive strength of the concrete increases and reaches 100% compressive strength at 28 days.

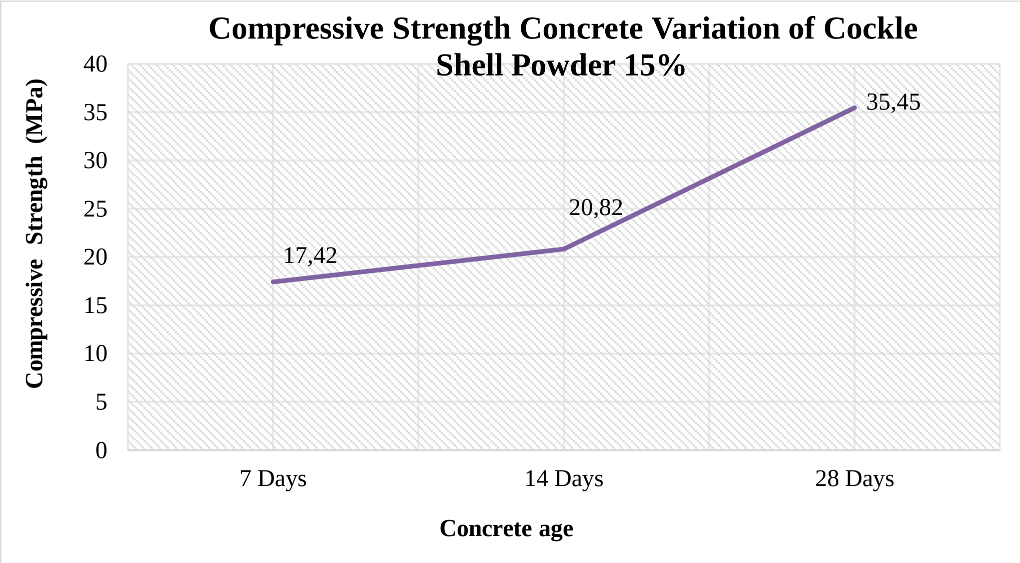

Figure 9. Compressive strength results of 15% cockle shell powder + 0.8% SP

Based on Figure 9. shows the results of concrete with variations of cockle shell powder 15% + SP 0,8% substitution at the age of 7 days of concrete of 17.42 MPa, for 14 days of concrete of 20.82 MPa and 28 days of concrete age of 35.45 MPa. So it can be based on the graph above, it be seen that the compressive strength of concrete has increased by 3.4 MPa on days 7 and 14 and on days 14 and 28 it also increased by 14.63 MPa.

Based on the results of concrete compressive strength tests on several variations of cockle shell powder substitution, it shows that the optimum compressive strength is when using 15% cockle shell powder which produces the highest compressive strength of 35.45 MPa. The higher the use of clam shell powder as a substitute for fine aggregate, the higher the compressive strength value. This is because cockle shell powder has adhesive properties when mixed with water in concrete mixes and has a slightly fine gradation category so that it plays an optimal role as a filler in concrete mixes. In addition, cockle shell powder has a mineral content similar to cement so that it can play a role in filling and binding other concrete materials.

4. CONCLUSIONS

The results of the concrete slump test show that normal concrete is 12 cm, concrete + SP is 12 cm and concrete with 5% cockle shell powder substitution variation is 12 cm, 10% cockle shell powder is 12 cm, 15% cockle shell powder is 11.98 cm. Based on the overall results of the slump test of normal concrete + SP and concrete variations of cockle shells powder all of which are included in the slump plan, the use of higher cockle shell powder or at a percentage of 15% produces the lowest slump value which indicates that concrete with fine aggregate substitution in the form of 15% cockle shells has a higher concrete density. The results of the concrete setting time test using 0.8% SP are very effective in increasing the compressive strength of concrete by 30%. Based on the results of the concrete compressive strength test of the 5%, 10%, 15% variation, it shows that the higher the use of cockle shells powder as a substitute for fine aggregates results in higher compressive strength. This is due to the cockle shells has adhesive properties when mixed with water in the concrete mixture and has a rather fine gradation so that it plays an optimal role as a filler in the concrete mixture. In addition, cockle shells powder have mineral content similar to cement so that they can play a role in filling and binding other concrete constituent materials. From the three variations of fine aggregate substitution, it can be concluded that the optimum use of cockle shells is 15%, which has the highest compressive strength value at the age of 28 days at 35.45 MPa.

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