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Planning Of Highquality Concrete Mixtures With Additional Superplasticizer And The Effect Of Partial Cement Replacement With Fly Ash

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Article Info	ABSTRACT
Corresponding Author: Name : **Fandhi Hernando** E-mail: fandhih06@gmail.com	Various studies and experiments in the field of concrete were carried out as an effort to improve the quality of concrete, material technology and implementation techniques obtained from the results of these studies and experiments were intended to answer the increasingly high demands on the use of concrete and overcome the obstacles that often occur in the implementation of the work. in the field. One way to increase the strength of concrete is to increase its compaction, which is to minimize the pores or cavities that form in the concrete. The use of admixtures can help solve these problems. The purpose of this study was to obtain the compressive strength of high-strength concrete and to determine the effect of the replacement of fly ash and the addition of a superplasticizer on the compressive strength of concrete. The composition of the Supeplasticizer mixture used in this study was 0.6% for all variations and the replacement of fly ash was 0%, 20%, 25%, 30% and 35% of the cement weight. The test object used was cylindrical in shape, the planned concrete quality was 65 MPa which was tested at the age of 28 days with treatment prior to testing. This study tested concrete with cylindrical specimens for compression test (diameter 150 mm and height 300 mm) as many as 50 samples and consisted of 5 variations and each variation was 10 samples. From the research, it was found that the highest compressive strength of concrete was found in the 20% Fly Ash replacement concrete mixture, which was 59.095 MPa and the lowest concrete compressive strength was found in the 30% Fly Ash replacement concrete mixture, which was 42.927 MPa. That with the replacement of 20% Fly Ash has a higher compressive strength compared to other Fly Ash mixed concrete variations. Mixture with a high degree of workability has a great risk of bleeding, this occurs in all concrete samples. **Keywords:** admixture, Superplasticizer, Fly Ash, concrete

INTRODUCTION

Development in the field of structure is currently progressing very rapidly, which takes place in various fields, such as buildings, bridges, towers, and so on. Concrete is one of the choices as a structural material in building construction[1]. Concrete is in demand because it has many advantages compared to other materials, including relatively cheap price, good strength, easy to obtain raw materials, durable, fire resistant, does not decay.[2]. Concrete technology innovation is always required to answer the challenges of demand, the resulting concrete is expected to have high quality including strength and durability without neglecting the economic value.[3]. Another thing that underlies the selection and use of concrete as a construction material is the factor of effectiveness and efficiency. In general, concrete fillers are made of materials that are easy to obtain, easy to process (workability) and have the durability and strength that are indispensable in a construction.[4]. From the properties of concrete, it makes concrete as an alternative material to be developed both in physical form and in the method of implementation.

Various studies and experiments in the field of concrete were carried out as an effort to improve the quality of concrete[5]. Material technology and implementation techniques obtained from the results of these studies and experiments are intended to answer the increasingly high demands on the use of concrete and overcome obstacles that often occur in field work.[6]. In the construction of high-rise buildings and other mass buildings high strength concrete is needed, high strength concrete is the most appropriate choice.

High strength concrete listed in SNI 03-6468-2000 (Pd T-18-1999-03) is defined as concrete which has a required compressive strength greater than 41.4 MPa. Efforts to obtain high-quality concrete are to improve the quality of the constituent materials, such as aggregate hardness and fineness of cement grains[7]. Improving the quality of concrete can be done by providing substitutes or added materials, from several substitute materials and existing added materials such as fly ash, besides being able to improve the quality of concrete, it can also affect stress and strain in concrete.[8].

Fly Ash is the residue from the coal combustion process that comes out of the furnace, while the rest of the coal combustion at the bottom of the furnace is called Bottom Ash[9]. Considering that the waste increases every year, it is necessary to overcome it. Fly Ash waste can cause quite a dangerous environmental impact, especially air pollution on the surrounding life[10]. Therefore, it is sought so that Fly Ash can be a useful material, including the use of Fly Ash, one of which is as a concrete mixture.

In this study, Sika Viscocrete-10 type Superplasticizer was also used, which is an added material that can facilitate the workability of concrete mixtures (workability) to be stirred, poured, transported and compacted. By adding this added material to the concrete mix, it is hoped that it will facilitate the work of mixing concrete. This is because Superplasticizer (Sika Viscocrete 10) is a mixed material for concrete that has multiple functions which, when mixed with a certain dose, can reduce the amount of water usage and speed up hardening time, increase workability and can reduce water content in the concrete mix, making high-quality concrete and making permanently impermeable concrete[11]. Testing of high-strength concrete with a compressive strength of 50 MPa, with a cube specimen of 15 x 15 cm, with a total sample of 10 samples, each variation using a mixture of Superplasticizer as a chemical added with a percentage between 0.4%-1.6%. For slump values of 7-10 cm and concrete testing was carried out at the age of 7 and 28 days with the optimum compressive strength of 70-72 MPa, namely the addition of a Superplasticizer as much as 1.4% and at the age of 20 days.

METHOD

Inspection of Materials used

The purpose of checking the silt content of the sand is to determine the content of the mud contained in the fine aggregate which will be used as a concrete mix material. In this aggregate the silt content should not be more than 5%.

Check the volume weight to determine the volume weight in the "SSD" (Saturated Surface Dry) condition. Specific gravity checks are carried out to determine the specific gravity of the aggregate to be used.

The sieve analysis aims to determine the grain distribution (gradation) of fine aggregate using a sieve. From the sieve analysis carried out, the fine modulus of the fine aggregate grains was obtained. The fine modulus is obtained from the cumulative percent of aggregate grains remaining on a set of sieves and then divided by one hundred (1 set of sieves #40, #20, #10, #4,8, #2,4, #1,2, # 0.60, #0.30 and #0.15 mm). The greater the mhb value, the larger the aggregate grains.

Calculation of concrete mix (Mix Design)

This procedure only applies to high-strength concrete produced using conventional materials and production methods. The calculation method used is SNI 03-6468-2000 (Pd T-18-1999-03). In this calculation, the values that need to be known before the calculation are: The required compressive strength f'c = 65 MPa at the age of 28 days. The sand used is natural sand, with the following characteristics: fineness modulus = 2.806; relative density (oven dry) = 2,631; absorption capacity = 3.092%; oven-dry solid density = 1962 kg/m3. The coarse aggregate used is crushed stone, the maximum size of the aggregate is limited to 20 mm with the following characteristics: Relative density (oven dry) = 2,583; absorption capacity = 2,944%, oven dry solid density = 1490,162 kg/m3. Coarse aggregate meets the gradation area No.

Added material to facilitate processing is used superplasticizer type Sika Viscocrete 10, the amount of dose used is all the same for each variation, which is 0.6%. The cement used is type I cement with a relative density = 3.15. The added material to replace cement is used fly ash (Fly Ash) derived from the coal-fired power plant waste PT. Sumber Segara Primadaya (S2P) Cilacap, based on the class used class C fly ash with relative density = 2.64. The initial slump after the addition of the binding retarder and before the superplasticizer is planned to be 25-50 cm. Mix proportions will be made based on laboratory trial mixtures.

For the manufacture of each sample used the results of the calculation of the new material requirements. At the time of making the sample, the water content contained in the aggregate and sand is checked again in the laboratory, because the influence of the water content in the aggregate and sand greatly affects the value of the cement water factor and the need for water to be used is cement, so the content of the cementitious material is used 438.642 kg/m3 concrete.

Test Object Manufacturing and Maintenance

The steps taken in the manufacture and maintenance of test objects are as follows:

a. The materials and tools that will be used for the manufacture of concrete (test objects) have been prepared in advance.
b. Laboratory examinations are carried out on the material to be used so that the planned quality of the concrete reaches the maximum strength according to the calculation, namely aggregate inspection which includes aggregate gradation (Fine Modulus of Granules), density inspection, and inspection of aggregate volume weight.
c. Planning the concrete mix (mix design). Every time you want to mix, the water content of materials such as coarse aggregate and sand is checked again, so that the water requirement used is calculated again.
d. Weigh the materials needed in accordance with those specified in the plan.
e. Mixing the ingredients is preceded by adding sand and portland cement, then stirring, adding gravel, water and additional ingredients (if using) alternately until all the ingredients are used up.
f. After the mixture is homogeneous, pour the mixture into the base of the concrete mix.
g. The slump value of the mixture is measured, if it is not in accordance with the planned slump value, put it back into the mixing bath to make adjustments with the addition of water.
h. After the slump obtained is in accordance with the plan, then the concrete mix is inserted into the cylindrical mold. Filling of the mixture is carried out in three stages, each 1 from the height of the mold. Each 3 stages compacted with steel rods (with a diameter of 16 mm and a length of 60 cm with rounded ends) 25 times.
i. After solid and full mold, then the surface is leveled.
j. After that, store the mold in a cool place, put it in a flat place and free from vibration and other disturbances and leave it for 24 hours. After 24 hours, the specimen is removed from the mould. Measure the height, diameter and weight and mark as necessary. Treatment was carried out by immersing the test object in an immersion pool for 28 days.
k. The test is carried out with a concrete press machine according to a predetermined age.

Testing the compressive strength of the test object

To carry out the compressive strength test of concrete, the following steps must be followed:

a. The tools and test objects to be used are prepared in advance.
b. the test object is tested by pressing machine. Place the test object on the press machine centrically (right in the middle) and then apply a compressive load with a constant increase in load ranging from 2-4 kg/cm2 per second.
c. Carry out the loading until the test object is destroyed and record the maximum load that occurs during the inspection of the test object.
d. Record the state of the test object.

Data processing

After the materials and test equipment are ready and the test sample has been made, it is ready to be tested according to research procedures. The results of the test are in the form of rough data that still needs to be processed further to find out the relationship/correlation between one test and another. In general, the tests that will be carried out will produce the effect of treatment and addition of additives on the quality of the concrete.

RESULTS AND DISCUSSION

The manufacture of the test specimens in this study was carried out by manual mixing, the concrete specimens for each variation were reduced by the proportion of cement and replaced with Fly Ash gradually starting from 20%; 25%; 30% and 35%, and by using the added material of Superplasticizer Sika Viscocrete-10 of 0.6% by weight of cement. The reason the researchers replaced some of the cement by using Fly Ash and using Sika Viscocrete-10 was to find out how much influence the changes in concrete strength caused by using a mixture of Fly Ash and Sika Viscocrete-10. The process in making concrete mix is as follows:

a. The initial process of making normal concrete specimens without partial replacement of cement with Fly Ash is manual mixing, preceded by adding sand and portland cement, then stirring, adding gravel, water alternately until all ingredients are used up, then stirring until the mixture looks homogeneous.
b. After the mixture is homogeneous, the slump value of the mixture is measured, if it is not in accordance with the planned slump value, the mixture is put back in to make adjustments with the addition of water.
c. After the normal slump obtained was in accordance with the plan, then the concrete was added with added material (Sika Viscocrete-10), then the slump value was measured again using Sika Viscocrete-10. After that, the mixture is put into a cylindrical mold. Filling of the mixture is carried out in three stages, each 1/3 of the height of the mold. Each 3 stages compacted with steel sticks 25 times.
d. For the manufacture of test specimens with partial replacement of cement using Fly Ash is to perform the steps as above, only the difference is in the amount of partial replacement of cement with Fly Ash, which is carried out after the proportions of cement and Fly Ash are stirred evenly and then mixed with coarse aggregate, fine aggregate and water until evenly mixed.

The most important thing that needs to be considered in all tests to be carried out is the surface condition of the test object. A flat surface will produce good compressive strength, stress-strain and modulus of elasticity because the load distribution will be evenly distributed over the entire surface of the specimen.

Table 1. Material Composition in Each Variation

Mixture	PC	Fly Ash	Water	Coarse Aggregate	Fine Aggregate	Superplasticizer
BN	745.8	-	293.560	549,735	675,780	0.6%

BP20	599,007	149.7519	288,324	550.4645	662.1704	0.6%
BP25	561,435	187.1451	288,613	552.7729	653.176	0.6%
BP30	523,817	224.4929	288,617	552.0162	648.1357	0.6%
BP35	487,445	262.4703	286,261	552.8834	645.9815	0.6%

Slump Value and Workability

Workability of concrete can be seen from the slump value that occurs. Because the slump value is a workability parameter, the higher the slump value, the easier the workability of the concrete. High strength concrete uses a low phase value, meaning that very little water is used, so the slump value is low. In this study, the slump value should be low, ranging from 25-50 mm because in high-strength concrete very little water is used, by adding superplasticizer (Sika Viscocrete-10) which can make the slump value higher than planned. In this study, the use of Superplasticizer (Sika Viscocrete-10) added material was the same for each variation, namely 0.6%. With the addition of Superplasticizer, it is hoped that a high level of workability will be obtained to achieve the appropriate slump value without bleeding and segregation. Superplasticizer is a chemical additive that has an effect in increasing the workability of concrete to a considerable extent.

One of the problems associated with the addition of superplasticizers in the concrete mixture is the rapid hardening of the mortar, making it difficult to perform a slump test. This happens in normal concrete mixtures with Superplasticizer (BN) after the fresh concrete is mixed it quickly hardens, with this condition before the concrete mix is printed it needs to be stirred manually again continuously so that the concrete mixture can return to plastic. Factors that affect the fast hardening of the mortar include the amount of addition of Superplasticizer, the type and amount of cement content, the time of adding the superplasticizer, humidity, temperature, mixing method and the use of other added materials. Each sample with the same Sika Viscocrete-10 addition of 0.6% for each variation of the concrete mix, has a different slump value. From the results of the research, it shows that the workability of the concrete mix that occurs is higher with the addition of Sika Viscocrete-10 compared to concrete without Sika Viscocrete-10 being added to the concrete mix. This is because Sika Viscocrete-10 itself is classified as a High Range Water Reducer which is able to improve the workability of the concrete mix and reduce the occurrence of bleeding and segregation. And Sika Viscocrete-10 is also used to slow down the hydration process, so that the cement hardening process becomes slower and the workability is high. It can be seen that normal concrete without Sika Viscocrete-10 application with slump values ranging from 25-50 mm can cause workability to decrease. In graph 5. 1 above, it can be seen that by adding concrete (Sika Viscocrete-10), the slump value that occurs is even better, it can even be said that the slump value that occurs when associated with the addition of Sika Viscocrete-10 will have an almost linear relationship. This means that in this study without reducing water and adding Sika Viscocrete-10, the slump and workability which should be small, can be avoided and the compressive strength of the concrete becomes better.

Judging from the replacement of the Fly Ash content, the slump value of the resulting concrete tends to increase. This is due to the very fine grain shape of Fly Ash which is the same as cement, round with a smooth surface, which is very good for workability, because it will reduce the demand for water or superplasticizer, so when Fly Ash is mixed in the concrete mix and added with Sika Viscocrete The hardening process in concrete is slow and the workability is high.

Analysis of the compressive strength of the test object

After making and maintaining the test object, then the compressive strength test of the test object is carried out. The compressive strength test of concrete was carried out on 28 days old specimens with a planned compressive strength (f'c) of 65 MPa for 50 samples using the SNI 03-6468-2000 method, which consisted of five variations. For each variation, 10 samples were made for the compressive strength of each variation with the addition of Fly Ash substitute of 20%-

35% of the cement weight and the addition of Sika viscocrete-10 fixed at 0.6% of the cement weight.

Table 2. Test Results of the Average Compressive Strength of Concrete

Test Item Code	*f'c*(Mpa)
BN	54,178
BP-20%	59.095
BP-25%	54,774
BP-30%	42,927
BP-35%	53.521

From the table above, it can be seen that the highest compressive strength of concrete is found in the Concrete Mixture with partial replacement of cement with Fly Ash 20% (BP-20%) which is 59.095 MPa and the lowest compressive strength of concrete is found in the Concrete Mixture with partial replacement of cement with Fly Ash. 30% (BP-30%) which is 42,927 MPa. From the data above, it can be seen that partial replacement of cement with 20% Fly Ash has a higher compressive strength compared to other Fly Ash mixed concrete variations. The effect of Fly Ash as a substitute material results in a binding reaction of free lime which is produced in the cement hydration process by the silica contained in Fly Ash. On the other hand, Fly Ash granules which are much smaller make the concrete denser because the voids between the aggregate grains are filled by Fly Ash so that it can minimize existing pores and take advantage of the pozzolanic properties of Fly Ash to improve the quality of concrete (can be seen in the explanation of point 3.5.1). The use of fly ash shows two effects of fly ash in concrete, namely as fine aggregate and as pozzolan. In addition, fly ash in the concrete contributes better strength than normal concrete.

In the concrete mixture test object (BP-30%) there are several problems including:

a. At the time of mixing the concrete is very difficult to stir after the addition of Sika Viscocrete-10.
b. When the cylindrical mold was opened, many samples of the cylinder had an uneven top surface, so that during testing the compressive strength of the concrete was not as expected.

Mixture with a high degree of workability has a great risk of bleeding, this occurs in all concrete samples. From the research, it can be seen that the use of Fly Ash can be used as a Filler. It can be seen from table 2 that the increase in compressive strength occurred in the concrete mixture with partial replacement of cement with 20% Fly Ash (BP20), partial replacement of cement with 25% Fly Ash (BP25) and partial replacement of cement with 35% Fly Ash (BP35). while the decrease occurred in the concrete mixture of partial replacement of cement with Fly Ash 30% (BP30). This is due to errors at the time of uneven mixing and during compaction. The addition of Superplasticizer does not really affect the compressive strength of concrete.

Discussion

In this study, the planned f'c was determined at 65 MPa, but from the results of the study, it was found that the f'c occurred at 59.095 MPa, said to have not fulfilled the planned f'cr. It is possible that this happens because of the strength of the coarse aggregate used, the coarse aggregate used is less hard. Coarse aggregate greatly affects the compressive strength of concrete, coarse aggregate is the most filling material in the concrete mixture, because of its large volume, coarse aggregate greatly affects the compressive strength of concrete. High-strength concrete listed in SNI 03-6468-2000 (Pd T-18-1999-03) is a concrete that has a required compressive strength greater than 41.4 MPa. For this reason, an aggregate wear test was carried out with a crackle test using a Los Angeles machine, namely the conditions for wear of the crushed part of the aggregate through sieve 1, 7 mm must be less than 27%, in this study the results of the aggregate wear value were more than the specified requirements of 41.26%. Thus causing the compressive strength of concrete is not in accordance with what has been planned that is equal to 65 MPa. Another possibility that occurs is because in this study the mixing of Sika Viscocrete-

10 added ingredients used the manual method so that the Superplasticizer mixture could not be perfectly evenly distributed and made the concrete mixture less homogeneous, so that when the mixture was inserted into the cylinder it was difficult. Because Sika Viscocrete-10 wraps the cement, it makes the mixture hard if it is left to stand and when it is removed it is liquid again and the coarse aggregate is not evenly distributed into the cylinder due to the separation between the coarse aggregate and the cement. In this study, the results of the aggregate wear value were that it exceeded the predetermined requirements of 41.26%. Thus causing the compressive strength of concrete is not in accordance with what has been planned that is equal to 65 MPa. Another possibility that occurs is because in this study the mixing of Sika Viscocrete-10 added ingredients used the manual method so that the Superplasticizer mixture could not be perfectly evenly distributed and made the concrete mixture less homogeneous, so that when the mixture was inserted into the cylinder it was difficult. Because Sika Viscocrete-10 wraps the cement, it makes the mixture hard if it is left to stand and when it is removed it is liquid again and the coarse aggregate is not evenly distributed into the cylinder due to the separation between the coarse aggregate and the cement. In this study, the results of the aggregate wear value were that it exceeded the predetermined requirements of 41.26%. Thus causing the compressive strength of concrete is not in accordance with what has been planned that is equal to 65 MPa. Another possibility that occurs is because in this study the mixing of Sika Viscocrete-10 added ingredients used the manual method so that the Superplasticizer mixture could not be perfectly evenly distributed and made the concrete mixture less homogeneous, so that when the mixture was inserted into the cylinder it was difficult. Because Sika Viscocrete-10 wraps the cement, it makes the mixture hard if it is left to stand and when it is removed it is liquid again and the coarse aggregate is not evenly distributed into the cylinder due to the separation between the coarse aggregate and the cement.

Stress-strain testing was not carried out on all test objects, 2 samples were taken from one variation totaling 10 samples. By paying attention to the picture of the stress-strain curve shown in Figure 1, it shows a decrease in the compressive strength of the concrete mixture for partial replacement of cement with 35% Fly Ash (BP35). This proves that the partial replacement of cement with Fly Ash and Sika Viscocrete-10 in the concrete mix has an effect on the compressive strength of the concrete. And if you look at the behavior after reaching the maximum stress in the concrete by replacing some of the cement with Fly Ash and the addition of Sika Viscocrete-10, the concrete can still maintain quite large stresses and strains. This shows that the partial replacement of cement with Fly Ash and the addition of Sika Viscocrete-10 makes the concrete more ductile. The area under the curve shows the amount of energy that can be absorbed during the loading process. The larger the area under the curve, the tougher the material.

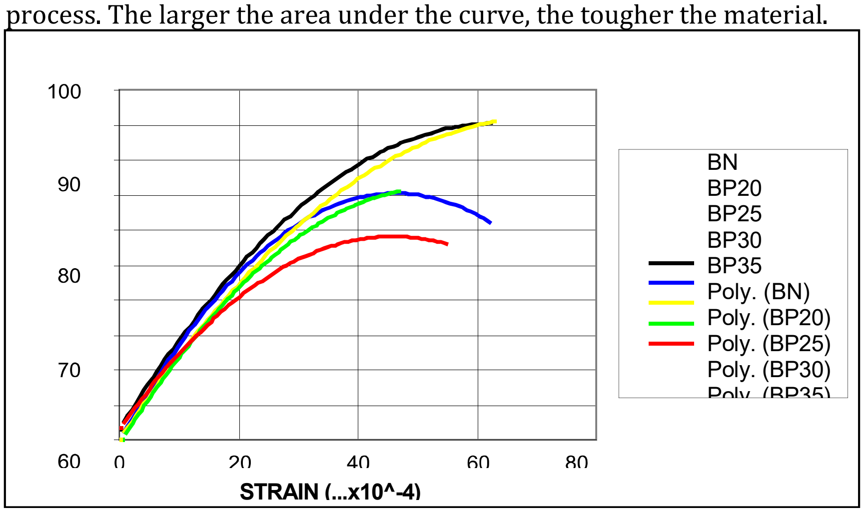

Figure 1. Concrete Stress-Strain Curve

The shape of the stress-strain curve is influenced by the characteristics of the aggregate used and the compaction factor. The weakest area in concrete is the area between the cement paste and coarse aggregate. The use of coarse aggregate of crushed stone that has a rough surface will reduce these weaknesses, so that it can increase the compressive strength and reduce the deformation that occurs due to loading.

The most important thing that needs to be considered in stress-strain testing is the surface condition of the test object. A flat surface will produce a fairly good value of the modulus of elasticity because the load distribution will be spread evenly over the entire surface of the test object.

The modulus of elasticity is a concrete property that relates to whether or not the concrete is deformed easily. And according to Edward G. Nawy, the modulus of elasticity is the slope of a straight line connecting the center point with a stress value (about 0.4.f'c), this modulus fulfills the practical assumption that the strain that occurs during loading can basically be considered elastic. On the stress-strain curve that about 40% of fc is generally considered to be linear with the assumption that the strain occurring during loading is assumed to be essentially elastic. The higher the strength of the concrete, the length of the linear section on the curve increases and there is a reduction in ductility when the strength of the concrete increases.

Table 3. Elasticity Modulus (Ec) Test Results

test object	Weight vol (kg/m3)	max (Mpa)	0.4σ max(Mpa)	(10-4) interpolation	Elastic Modulus (MPa)	
					Test (0.4f'c/ε)	Theoretical 0.043*Wc^1.5*√f'c
BN	2309.253	90.00	36.00	12,330	29197.080	45268,579
BP20	2320.725	70.00	28.00	10,780	25974.026	40221.007
BP25	2255.099	91.15	36.46	15,100	24145,695	43963805
BP30	2249,762	68,848	27,539	12,371	22261,094	38073,171
BP35	2306,253	58.00	23,200	9.282	24994.613	36269,617

In this study, the maximum compressive strength of concrete aged 28 days was obtained at 25% Fly Ash replacement variation, which was 91.15, the concrete sample had a test modulus of elasticity of 24145,695 and a theoretical modulus of elasticity of 43963.805.

The magnitude of the elastic modulus is strongly influenced by the characteristics of the aggregate. The weakest area in concrete is the area between the cement paste and coarse aggregate. Some samples of concrete experienced a decrease in the elastic modulus due to lack of control over the workmanship and in the compaction factor of the concrete. Concrete with poor compaction will cause porous between the aggregates so that the bonding power between the aggregates becomes weak. Concrete with high compressive strength will have a high elastic modulus. In addition, to get a high modulus of elasticity that needs to be considered in stress-strain testing is the surface condition of the test object, the flatter the surface of the test object, the better the results.

CONCLUSION

From the results of research that has been carried out, the following conclusions can be drawn: For high-strength or very high-strength concrete, the slump value ranges from 25-50 mm, therefore to make the work easier, a Superplasticizer (Sika Viscrocrete-10) must be added. All mixed variations use fixed phase. The optimum compressive strength was achieved by replacing cement with 20% Fly Ash, which was 59,095 MPa. The compressive strength of the plan cannot be achieved, because in this study the coarse aggregate used is less hard. In this study, the substitute material, namely Fly Ash, cannot replace cement.

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