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The Effect of Roving Fibers Addition on the Compressive and Tensile Strength of No-Fines Concrete

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***Abstract:** The addition of fiber in the concrete mixture has proven to increase the tensile strength of concrete for non-structural purposes. Natural materials and easily obtainable can be generally used for non – structural purposes. This study was aimed to investigate the effect of roving fiber addition on the compressive and tensile strength of the no-fines concrete. The results of this study were expected to be an input for the society, especially for the construction materials industry, and can be useful for further research. The test specimens used in this study, for each type of variable, were 3 cylinders for compressive strength test and 3 cylinders for tensile strength test. The volume ratio between the cement and gravel on the mixture was as follows: 1: 5, 1: 6, 1: 7, 1:8, 1: 9. In addition, the length of the roving fibers used in this study was 3 cm. The addition of roving fibers of each mixture was 0%, 2.5%, 5%, 7.5%, 10% of the weight of the cement. The results showed that the addition of roving fiber increased the compressive strength and tensile strength of no-fines concrete. The optimal compressive strength was achieved at the 5% addition of fiber roving. Furthermore, the optimal splitting tensile strength of concrete was achieved on the 5% addition of fiber roving.*

***Keywords:** Concrete Strength, Fiber Roving.*

I. INTRODUCTION

Concrete is a construction generally composed of cement, aggregate, and water. The concrete is now not only used for the structural purposes, but can also for non-structural purpose. Many non - structural components of the building are made of walls, practical columns, home furniture, and various decorations.

The use of concrete in non-structural components is certainly different from the structure in which the composition is designed in such a way as to produce concrete with aesthetic value as well as from the economic aspect.

One of concrete products for non – structural and light structure is no-fines concrete. Compositions that does not include fine aggregate in the manufacture can reduce the specific gravity of the concrete.

In addition, the absence of fine aggregates can lead to porosity in the concrete caused by cavities unfilled by smaller materials.

High porosity in no-fines concrete does not allow the use of reinforcing steel to withstand the tensile force. It is caused by the weakness of the steel material to corrosion caused by the water oxidation process which enters the gap of the no-fines concrete. One of the attempts to overcome this problem is by replacing steel reinforcement as the material withstanding the tensile force in the composite component of concrete with synthetic fiber material. One of the replacements for the reinforcing steel is roving fiber.

Roving fiber is one of the obtainable material with the affordable price. The roving fiber is widely used in the manufacture of gypsum. It is chemical - resistant, has water-resistant surface to prevent the occurrence of clod during the mixing process. In this case, the use of roving fiber as a substitute for reinforcing steel in no-fines concrete can add tensile strength.

The aim of this study was to know the amount of fiber content that produced the optimal compressive strength and splitting tensile strength of no-fines concrete.

II. LITERATURE REVIEW

A. No-Fines Concrete

According to [5], no-fines concrete is a simple form of lightweight concrete which does not use fine aggregate. The non-use of fine aggregates in this concrete composition results in a reduction in the specific gravity of the concrete because the emergence of pores on the concrete which can reach 20 – 25 percent. The main advantages of this no – fines concrete are as follows:

a. More heat insulation
b. Faster and simpler manufacturing process
c.Light weight

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d. Slight shrinkage
e. There is no tendency to segregate so that it can be dropped with a higher falling height
f. Minimal use of cement (since there is no sand, the aggregate grain surface area is reduced leading to the reduced need for cement)
g. Permeable

Porosity in no-fines concrete results in the reduced strength of the concrete. Therefore, it is impossible to use reinforcing steel as no-fines concrete composite material as it triggers corrosion acceleration in the steel.

Specific gravity of no-fines concrete is influenced by aggregate gradation which ranges from 60-75% from ordinary concrete. The size of the coarse aggregate which is generally used is 10 mm - 20 mm. The use of aggregates with tight gradations and sharp surfaces (crushed rocks) produces no-fines concrete with a slightly higher compressive strength and density than using uniform and round aggregates (gravel).

The water cement ratio in no-fines concrete ranges from 0.36 - 0.46 because if the water cement ratio is too low then the cement will not be sufficient to cover the surface of the coarse aggregate. On the other hand, if the water cement ratio is too high then the cement will be too diluted. As a consequence, at the time of solidification, the mortar settles at the bottom.

[5] who investigated no-fines concrete made from the fraction of ceramic tile found that the no – fines concrete with 0.40 cement water ratio and reached the optimum compressive strength reaching 5 MPa - 10 MPa for the cement and aggregate volume ratio 10 to 6. In addition, Akhmad Subhannur (2002) who used gravel from Mount Merapi in his study found that the compressive strength of the non – sand concrete was 18 MPa, if the ratio of cement and aggregate volume was 4. The compressive strength of the no – fines concrete was 4 MPa, if the ratio of cement and aggregate volume was 10 with constant cement water ratio of 0.40.

Due to the relatively low compressive strength, the no-fines concrete is used only for non-structural parts, such as concrete or brick walls. However, it is also used for lightweight structural parts of a simple home.

B. Fibrous Concrete

Fibrous concrete is a mixture of concrete and fiber, generally in the form of rods with a size of 5 - 500 μm, with a length of 25 mm. The fiber material may include asbestos fibers, plastic fibers *(polypropylene)*, or a piece of steel wire. The downside of the fibrous concrete is that it is difficult to produce. However, it has more advantages including the possibility of small segregation, ductile, and impact resistant [2].

The use of fiber in fibrous concrete is now highly developed. This is marked by the emergence of new innovations in the use of natural and synthetic fibers in concrete.

Fibers from natural materials such as plant fibers, palm fiber, bamboo, and coconut husks can be used for non-structural concrete. The advantage of fiber reinforcement is that it can prevent too early concrete cracks caused by either from hydration heat or loading. In addition, it is resistant to damage in concrete which has a high porosity level.

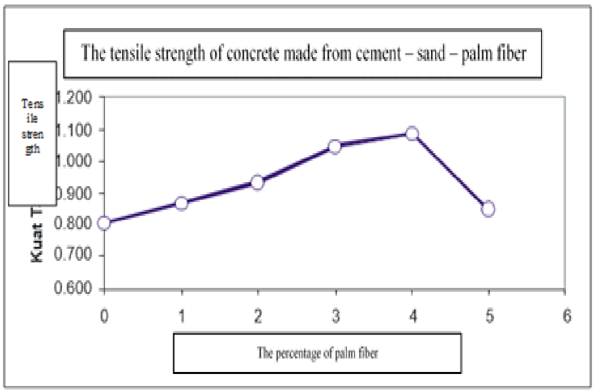
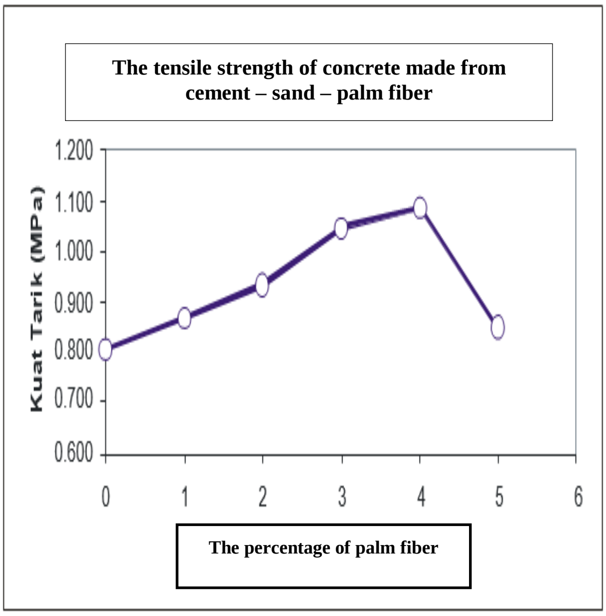


Fig 1. The tensile strength of concrete made from cement – sand – palm fiber with percentage of palm fiber addition.

Fig 2. The compressive strength of concrete made from cement – sand – palm fiber with percentage of palm fiber addition



The cement to sand ratio was 1:11and the length of the palm fiber was 2,5 cm. The addition of the palm fiber was 1 – 5 % form the weight of the cement. BI-0 was the code for the specimen without palm fiber. BI-1 was the code for the specimen with 1% fiber. BI-2 was the code for the specimen with 2% fiber. BI-3 was the code for the specimen with 3% fiber. BI-4 was the code for the specimen with 4% fiber. BI-5 was the code for the specimen with 5% fiber.

The use of fiber leads to reduced ease of producing and prevention of segregation. Fiber in concrete is useful to prevent cracks. Therefore, fibrous concrete is more ductile than conventional concrete.

C. Crude Fiber (*Roving Fiber*)

Roving fiber (rough fiber) is fiber made of polyster / epoxy, used a middle layer medium of fiberglass plate. Polester is a synthetic material made of *purified terephthalic acid (PTA)* or *dimethyl ester Dimethyl Terephthalate (DMT)* and *Mono Ethylene Glycol (MEG).*

Fig 3. Physical Form of Roving Fiber [1]

The use of this fiber is quite extensive as an inner composite reinforcement of vehicles or cruise ship and gypsum product. [6] showed that the specific gravity of roving from the investigation of the two samples was 1,364 g/cm^3

III. METHODS OF THE STUDY

The aim of this study was to investigate the amount of fiber content that can produce the optimal compressive strength and tensile strength of no-fines concrete.

The study was an experimental study. This study investigated the compressive strength and splitting tensile strength of no – fines concrete by adding roving fiber with this following percentage;

0%, 2.5%, 5%, 7.5% and 10% from the weight of the cement and with the aggregate ratio: 1:5; 1:6; 1: 7; 1: 8 and 1: 9 and water cement ratio of 0.4.

The cement used in this study was Holcim and PCC cement which was widely used in the market. PCC cement is a cement which has a maximum bond strength more than 28 days. The coarse aggregate used in this study was the aggregate from Kali Garang river with a maximum 20 mm grain having a natural surface. The natural aggregate of its binding strength is less than the crushed aggregate.

Tests carried out in this study included rough aggregate testing, cement testing, compressive strength testing and tensile strength of no-fines concrete with the diameter of the test specimen 15 cm x 30 cm.

Concrete compressive strength is the strength which was determined by pressing the top surface of the concrete until it achieved the maximum strength to withstand the applied load. The tensile strength is the tensile strength of concrete determined based on the splitting compressive strength of the concrete cylinders pressed on the length side [3]

The study was conducted at the Laboratory of Civil Engineering Department, Universitas Negeri Semarang starting from material testing, specimen making, specimen treatment, and specimen testing. This study was conducted after all the preparation of the materials was completed. The purpose of this study was to figure out the level of fiber content that could result in the optimal compressive strength and tensile strength of the no – fines concrete. The following was flowchart of this study:

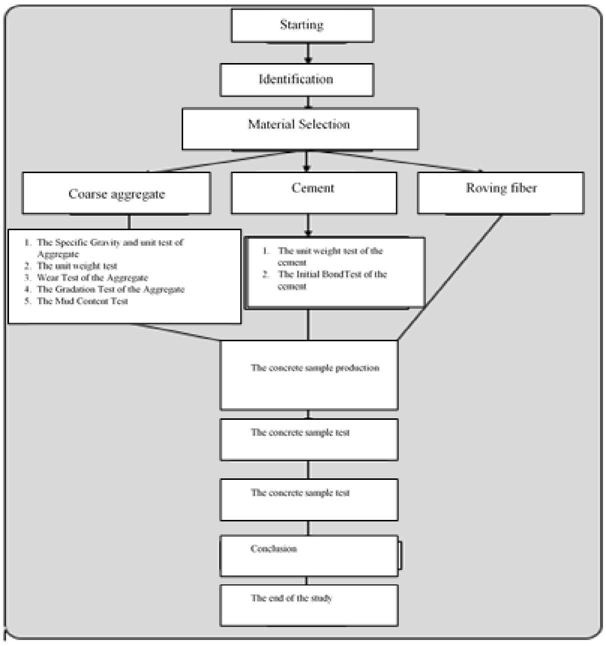


Fig 4. Flow Chart of Research

This study began by selecting the materials of no-fines concrete. Several tests were conducted to the cement and coarse aggregate.

The results of the coarse aggregate testing showed that the specific gravity testing of the coarse aggregate was 2, 33. It showed that the specific gravity of the coarse aggregate is below the normal aggregate weight (Normal weight of the coarse aggregate is between 2.5 and 2.7 . [5].

The result of unit weight test of coarse aggregate was 1,572. Therefore, the unit weight aggregate is considered as normal aggregate.

The aggregate used in this study had the maximum size of 20 mm. 94.5% of the aggregate passed the 19 mm sieve. 8.8% passed the 9.5 mm sieve. 1.67% passed the 4.75 mm sieve. When these results were compared with aggregate gradation test, the coarse aggregate should not be used for structural building materials. However, they were used for non-structures.

From the result of coarse aggregate wear test, sample 1 resulted in wear of 35.22%, while sample 2 was 36.26%, the average wear was 35.74%.

The results of the study showed that the weight of sample unit for cement, sample 1 was 1095 kg / m3; sample 2 was 1105 kg / m3, and the average weight was 1100 kg / m3. The vicat test showed that the early cement bonds occurred at 123 minute and the final cement bond occurred at 255 minute.

Cylindrical specimens with size 15 x 30 cm was made in this study. Furthermore, the preparation of the specimen was carried out by using the proportion of a mixture of cement and a coarse aggregate of 1:5, 1:6, 1:7, 1:8 and 1: 9 with 0.4 cement water ratio. The production of specimens used coarse aggregate in the form of gravel from Kaligarang River and roving fiber in no-fines concrete mixture with the following percentage: 0%; 2.5%; 5%; 75% and 10% out of the weight of cement.

The needs of the material can be seen in the following table.

Table 1. The variable of the study

The cement : aggregate composition	The size of the fiber (cm)	f.a.s	The percentage of fiber out of the concrete weight	F'c	ft
01:05	3 cm	0,4	0	3	3
			0,25	3	3
			5	3	3
			7,5	3	3
			10	3	3
01:06	3 cm	0,4	0	3	3
			0,25	3	3
			5	3	3
			7,5	3	3
			10	3	3
01:07	3 cm	0,4	0	3	3
			0,25	3	3
			5	3	3
			7,5	3	3
			10	3	3
01:08	3 cm	0,4	0	3	3
			0,25	3	3
			5	3	3
			7,5	3	3
			10	3	3
01:09	3 cm	0,4	0	3	3
			0,25	3	3
			5	3	3
			7,5	3	3
			10	3	3

After the specimen was made and it was treated for 28 days. Then, the test of compressive strength and permeability test was conducted to the concrete specimen.

IV. RESULT AND DISCUSSION

The compressive strength and tensile strength tests were conducted after the concrete was 28 days old.

The graph of the compression strength test and tensile strength are presented in the following figure :

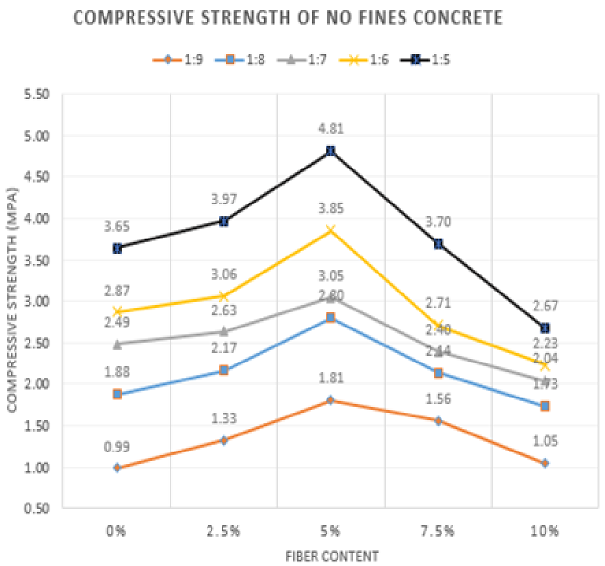


Fig 6. The Compressive Strength of the No-Fines Concrete

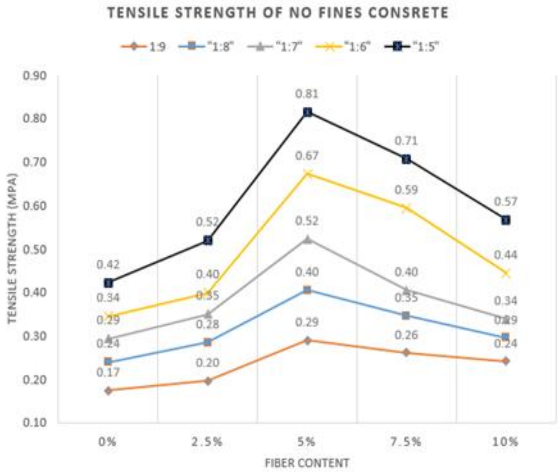


Fig 7. The Tensile Strength of the No-Fines Concrete

The two graphs above show that the compressive strength test and the tensile strength of concrete with five different aggregate comparisons begin to increase in the percentage of 2.5% fiber addition, and achieve the optimum value at 5% fiber addition. However, the compressive strength and the tensile strength start to drop at 7.5% and then decline at the addition of 10% fiber.

The graph shows that the most optimal compressive strength and splitting tensile strength were achieved at 5% roving fiber addition because the proportion of concrete with the addition of 5% roving fiber is the most optimal proportion compared with other proportions. Other materials of the concrete in the form of aggregate and cement were still able to bind the other materials in the form of roving fiber.

Roving fiber is very light weight. Therefore, it did not affect the weight of the concrete significantly. The weight of the concrete only increased for about 1% every addition of fiber composition. It can be concluded that the addition of roving fiber with concentration up to 5% made the concrete more solid. The ability of the cement to cover or bind the aggregate and 5% % roving fiber addition was the most ideal composition.

Fig 8. Collapse due to testing

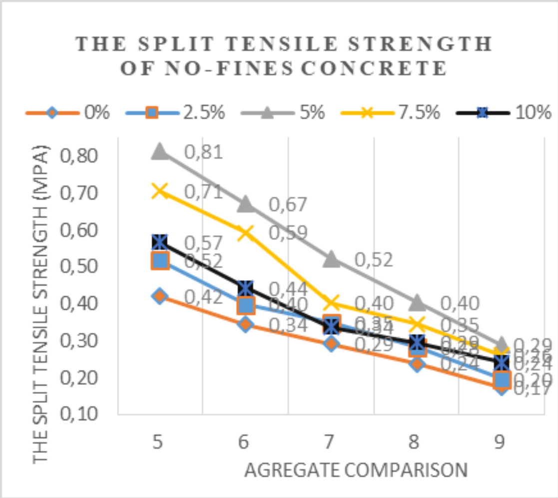


Fig 9. The relationship of aggregate comparisons with tensile strength of concrete.

From the Fig. 9 with the similar percentage of fibers, if the aggregate ratio is higher then the splitting tensile strength value will decrease due to the less use of cement, thus reducing the strength of the bond strength

V. CONCLUSION

From the results of the study, it can be concluded that

1. The use of roving fiber influenced the compressive strength of concrete. The highest compressive strength found in the use of 5% roving fiber was 1.81 MPa in the ratio 1: 9. The compressive strength of 2.80 MPa was found in the ratio 1:8. The compressive strength of 3.05 MPa was found in a ratio of 1: 7. The compressive strength of 3.85 MPa was found in a ratio of 1: 6. The compressive strength of 4.81 MPa was found at a ratio of 1: 5. The lowest compressive strength which was found with 0% roving fiber was 1. 05 MPa in the ratio of 1: 9; 1.73 MPa in the ratio of 1: 8, 2.04 MPa at a ratio of 1: 7; 2.23 MPa at a ratio of 1: 6; and 2.67 MPa at a ratio of 1: 5.
2. The highest tensile strength of the no-fines concrete was found in the ratio of 1: 9, 1: 8, 1: 7, 1: 6 and 1: 5 in the use of 5% roving fibers. The tensile strength values were 29 MPa, 0.40 MPa, 0.52 MPa, 0.67 MPa and 0.81 MPa. On the other hand, the lowest value of tensile strength was found in the use of 0% roving fiber with these following values: 0.17 MPa at a ratio of 1: 9; 0.24 MPa at a ratio of 1: 8; 0.29 MPa at a ratio of 1: 7; 0.34 MPa at a ratio of 1: 6; and 0.42 MPa at a ratio of 1: 5.

SUGESTION

1. This research was supported by Ministry of Research and Higher Education and Directorate General of Railway, Sub-Directorate Investment, Ministry of Transportation, Republic of Indonesia. It is expected that no-fines concrete can be applied as non-structural ornaments such as flower pots, pedestrian roads, tables, fences and so on.

2. For the next study, innovations in the next study with more variations in cement to water ratio and concentrations of fiber *rovings* or the use of other additives need to be investigated.

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