# EFFECT OF CHICKEN FEATHER WASTE ON THE CONCRETE MIXING ON COMPRESSIVE STRENGTH AND FLEXURAL STRENGTH

**Sutarno Sutarno, Diah Rahmawati, Hendra Masvika**
Civil Engineering Departement, Universitas of Semarang, INDONESIA
E-mail: tarno_usm@yahoo.com

## ABSTRACT

The materials that are often used in the world of construction both in bridges, water structures, and buildings is concrete. The characteristic of concrete is that it is strong withstand compressive forces, but weak in resisting tensile forces. Therefore, it is necessary to improve the characteristics of the concrete. Improving the characteristics of the concrete can be done by applying a fiber mixture to the concrete. There are two types of fibers used as a concrete mixture, namely synthetic fibers and natural fibers. The research conducted was concrete using chicken feather waste fiber which was categorized as natural fiber with a fiber length of 3 cm, the grade of the concrete used was 20 MPa and the percentage of additional chicken feather waste was 0%, 1%, and 2% of the volume of concrete. The test is the compressive strength and flexural strength of the concrete using a specimen cylinder 15x30 cm and beam 15x15x60 cm. Each percentage of chicken feather waste that is used as a concrete mixture is 5 samples. From the test results, it was found that the concrete with the addition of 0% chicken feathers obtained an average compressive strength value of 200.78 kg/cm$^2$, concrete with the addition of 1% chicken feather fiber, the compressive strength value increased to 215.09 kg/cm$^2$ and concrete with the addition of chicken feather fiber 2 % has a compressive strength value of 197.54 kg/cm$^2$. Meanwhile, the flexural strength values obtained were 24.00 kg/cm$^2$, 23.03 kg/cm$^2$, 21.08 kg/cm$^2$ for the percentage of 0%, 1% and 2% fibers, respectively. This shows that the concrete with the addition of bristle fibers the chicken has decreased the compressive strength value when it has reached its optimum level. While the addition of the percentage of chicken feathers to the flexural strength value does not have much effect on the flexural strength of the concrete which tends to decrease. This is influenced by the characteristics of the chicken feathers which are difficult to bond with the concrete as well as being easy to absorb water, so that the concrete takes a longer time to dry after the maintenance of the concrete.

**Keywords:** concrete fibers; waste chicken feathers; compressive strength; flexural strength.

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## INTRODUCTION

Currently the government is conducting infrastructure development. Infrastructure development is one of the efforts made to carry out the construction of physical facilities and infrastructure. Infrastructure development that is being implemented is the construction of roads, toll roads, ports and airports. In addition to the implementation of road construction, toll roads, ports and airports, also being carried out the construction of buildings, namely hospitals, schools and other buildings.

In the implementation of construction of both buildings, water buildings and bridges, using materials called concrete. One of the properties that become the advantages of concrete is being able to withstand compressive strength. Another property of concrete is that it is resistant to fire. In addition, when viewed aesthetically, concrete requires little maintenance. Besides the advantages of concrete properties above, concrete also has some drawbacks. One of the shortcomings of concrete is that it can experience deformation and shrinkage due to drying of concrete.

The advantages of concrete that is strong resist the press must be accompanied by ease in working on it. In producing concrete with high strength, the concrete must have a small factor of cement

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water. This causes difficulties in the workmanship. To overcome this, the concrete is given a mixture in addition.

Additional materials as a mixture of concrete are called fibers. Fiber there are two kinds of synthetic fibers and natural fibers. Synthesis fibers are derived from glass, steel and polymers. While the natural fibers can be derived from plants such as palm fiber, straw, bamboo, coconut fiber and others. In addition to the above fibers, according to Williams, et all. (1991) in Handani and Efilusi (2011), chicken feather fibers can be used as an alternative amplifier in addition to synthetic fibers such as plastic because chicken feathers composed of keratin have a cystine disulfide bond that tends to bind to each other thus making it strong, tough and light. Therefore, it is necessary to have research on concrete with a mixture of chicken feather waste. Therefore, it can be known the magnitude of the compressive strength and flexural strength by using a mixture of chicken feather waste.

Added materials in concrete mixture are indispensable. The amount of additional material in the concrete mixture varies and depends on the percentage of the amount of additional material used as the concrete mixture itself. The additional mixed material is used to increase the compressive strength of concrete, where normal concrete strength will be different from concrete strength by using additional materials as mixtures.

Chicken feathers can be classified in synthetic fibers. Chicken feathers have a tendency to bond with others. Because chicken feathers have a cystine disulfide bond. This is the reason for the research with the addition of chicken feather waste. Therefore, it is necessary to conduct a study on the influence of the addition of chicken feather waste in concrete to the value of compressive strength and flexural strength of the concrete itself. As well as how the value of compressive strength and flexural strength concrete when compared to normal concrete (concrete with additional chicken feathers 0%). Therefore, the purpose of this study is to know the contribution of chicken feather waste to the compressive strength and flexural strength of concrete and know the contribution of chicken feather waste to the compressive strength and flexural strength of concrete compared to using normal concrete.

**Concrete**

Concrete is a mixture of aggregate, cement, and water. Aggregate is a filler material consisting of natural mineral granules. As a filler material, the aggregate content is 60% to 70%. The aggregates used as the main constituent materials of concrete are fine aggregates (sand) and coarse aggregates (gravel). Therefore, aggregate quality greatly affects the properties and quality of concrete.

Coarse aggregates (gravel) have a granule size of more than 4.8 mm in diameter. According to Mulyono (2005) the terms of rough aggregate used as a concrete mixture are as follows:
1. Fine modulus grains 6.0 to 7.1.
2. Sludge content or parts smaller than 70 microns (0.074 mm) maximum 1%.
3. Weak content if tested with a maximum copper rod scratch of 5%.
4. Conservation if tested with sodium sulfate the maximum crushed part is 12%, and if used magnesium sulfate the maximum crushed part is 18%.
5. It is not reactive to alkalis if the alkaline content in cement as $Na_2O$ is greater than 0.6%.
6. Does not contain long, flattened granules of more than 20%.

Fine aggregates (sand) have a granule size less than 4.8 mm in diameter. According to Tjokrodimulyo (2007) the terms of fine aggregate used as concrete mixture are as follows:
1. Fine aggregates for concrete can be sand directly from nature or artificial sand derived from shards of rock.
2. Fine aggregate grains should be sharp and hard so that they are not easily crushed.
3. Fine aggregates should not contain more than 5% mud.
4. Fine aggregates should not contain too much organic matter.
5. The fine modulus of the grain is between 1.50-3.80.
6. Sea sand should not be used as a fine aggregate for all concrete qualities, unless it is based on the instructions of the recognized material inspection agency.

While the requirements according to SNI 03-1750-1990 in Amri (2005) for fine aggregate grains as follows:
1. The remainder on the 4.0 mm sieve must be a maximum of 2% by weight.
2. The remainder on the 1.0 mm sieve must be a maximum of 10% by weight.
3. The remainder on the 0.25mm sieve should range from 80% to 95% by weight.

Both aggregates are both coarse aggregates and fine aggregates when mixed with cement and water, the hydration process will occur. The hydration process is a chemical reaction of cement and water that produces heat (Murdock and Brook, 1991 in Elhusna et all., 2011).

Portland cement is hydrolysis cement. Portland cement is obtained from clinker smoothing. Portland cement consists of calcium silicate (hydrolysis) and gibs (auxiliary material). Cement is used as an adhesive between aggregate granules when mixed with water. The volume of cement used is approximately 7-15% of the concrete volume. According to Antoni and Nugraha (2007), cement is a key element in concrete although the amount is only 7-15% of the total mixture.

Water is used as a mixture of aggregate and cement. Water serves to make cement paste in the process of chemical reactions that is the process of hydration. The hydration process occurs at the time of concrete compaction and concrete treatment. As a cement paste material, the amount of water should not be too much, because the excess water will reduce the strength of concrete. The excess of adding water can cause the water to rise together with the cement onto the concrete mix, so that the attachment will be reduced (Chayati and Widodo, 2016). Similarly, if the amount of water is small will make the hydration process uneven.

Water used as a mixed material in the manufacture of concrete must meet the requirements. The requirements for the water are as follows:
1. Water should not contain more than 2 grams of mud per liter
2. Water should not contain salt and acid more than 15 grams per liter, since salt and acid can damage concrete.
3. Water should not contain chloride more than 1 gram per liter.
4. Water should not contain more than 1 gram of sulfate per liter.

From the mixture between aggregate, cement and water, it will produce concrete properties. The concrete has advantages and disadvantages. Some of the advantages of concrete properties are:
1. Materials are easy to obtain, raw materials are available in nature.
2. Strong holding force press.
3. Easy to transport and print.
4. Easy repair process by spraying fresh concrete into cracked concrete (grouting).
5. Make it easier to pour in difficult places by using concrete pump.
6. Resistant to the influence of high temperatures and wear resistant.
7. Maintenance is relatively easy and cheap.

While the disadvantages of the nature of concrete are:
1. Not strong to withstand tensile force.
2. Not waterproof, so when entering water containing salt can damage concrete.
3. Non ductile (brittle).

**Concrete Fiber**

Concrete structurally has a high compressive strength while the tensile strength is low. The strengthening of concrete structure elements on the tensile part can be strengthened by the addition of fibers. The selection of concrete fibers in terms of type, shape, quantity, and aspect ratio affects the tensile strength of concrete (Antonius, et all., 2014).

Concrete fiber is concrete provided additional materials in the form of fibers. Fiber consists of synthetic fibers and natural fibers. Synthesis fibers are usually steel, glass, asbestos, carbon and polymer. While natural fibers are derived from plants such as hemp, palm fiber, bamboo, cotton and

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coconut fiber. The selection of plant fibers is usually more for non-structural concrete purposes, considering the durability of natural fibers is relatively non-durable.

Concrete with the addition of natural fibers derived from plants can improve the characteristics of concrete. The addition of fiber as a concrete mixture according to Daniel et all., (2002) is able to improve some concrete characteristics namely increasing tensile strength, compressive strength, elastic modulus, crack resistance, crack control, durability, fatigue life, resistance to shock loads, resistance to abrasion, shrinkage, thermal characteristics and fire resistance.

Fibrous concrete with normal quality has a ductile behavior, namely fiber concrete when it deforms significantly without losing any meaningful strength (Antonius, et all., 2012). Theoretically the brittle nature of concrete can be retained by fiber. The addition of fiber at certain volume dramatically affects the compressive strength of concrete at 14 days and 28 days of concrete (Rulhendri et all., 2013). In addition, the provision of fibers in concrete can add strength and reduce deflection. This can be seen in the following image.

The strength of concrete is influenced by the quality of the construction material, the building blocks of concrete consist of a mixture of coarse aggregate, fine aggregate and added portand cement and water (Marwahyudi.M, 2020); (Putranto.F.R, Syaiful.S, 2019). To increase the strength of the concrete, additives can also be added, in addition to accelerating the hardening, it also increases the life of the betoon. High quality and high quality concrete for structures, especially on the highway (Mubarak.M, et.al, 2020); (Syaiful.S, 2020).

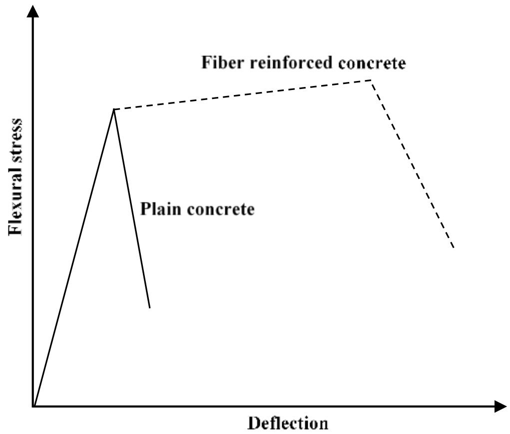


**Figure 1.** Flexural Performance of Fiber Reinforced Concrete and Plain Concrete (Mastali, et all., 2015)

**Chicken Feather Waste**

The increase in the chicken farming industry has an impact on the increase in waste in the form of chicken feathers. Chicken feather waste that is not used and thrown away can cause unpleasant odors, disease nests, and environmental pollution (Mulia, et all., 2016). Therefore, it is necessary to process chicken feather waste using environmentally sound technology in accordance with the principle of zero waste. Utilization of chicken feather waste as fiber in concrete is one part of the solution carried out in this study.
Chicken feather waste fibers belong to the type of natural fibers, which can be used as non-structural concrete fibers. Chicken feather fiber can be used as an alternative amplifier in addition to synthetic fibers, because chicken feathers are composed of keratin or fibrous proteins in the form of fibers that are strong and light (Handani and Efilusi, 2011). As known keratin is a product of hardening epidermal tissues of the body such as nails, horns, hair and fur. According to Setiawan (2012) in Putri and Wardhono (2017), keratin properties are tight and binding, then chicken feathers can be used as a substitute for fiber reinforcement fiber.

The utilization of chicken feather waste as fiber in concrete is intended to increase the strength of concrete tensile as well as support environmental function policies, as Act No. 23 of 1997 about

Environmental Management. The use of chicken feather fiber as roof fiber is done by Handani and Efilusi (2011) by varying fiber composition. The use of chicken feather fiber by 30% contributes to the optimum value of press strength of 38 MPa and flexural strength of 27.8 MPa. The addition of chicken feather fibers above the figure of 30% linearly causes a decrease in the value of compressive strength and flexural strength due to inability to bind.

Mixing mortar in the form of cement and sand with the addition of chicken feather fibers is done by Putri and Wardhono (2017) in the making of GRC wall panels. Variable composition of chicken feather fiber is given by 10%, 20%, 30%, 40%, and 50%. Mechanical capability test results provide a flexural strength and compressive strength of 31.3 MPa and 29.1 MPa respectively, at a percentage of 40% chicken feather fibers with a specimen age of 28 days.

## RESEARCH METHOD

### Time and Research Location

The sample making site is conducted at PT. Nurcahya Jaya Mandiri (NJM) Demak, while for the sample testing site was conducted in the Laboratory of Materials and Structure of the Universitas Semarang and in NJM Demak. This research was conducted in the period 2020-2021 during 4 months of testing time.

### Equipment and Materials

Equipment that used to make concrete specimen are as follows:

1. Concrete Mixer
2. Cylinder Mold
3. Beam Mold
4. Compression Machine
5. Hydraulic Concrete Beam

The materials used in this study are:

1. Portland cement
2. Rough aggregate
3. Fine aggregate
4. Chicken feather waste
5. Water

The specimens in this study can be explained as follows:

a. Compressive strength test

**Table 1.** Specimen of Compressive Strength Test

| Specimen | Diameter (d) cm | Height(h) cm | Sample |
|---|---|---|---|
| Fiber concrete cylinder 0% | 15 | 30 | 5 |
| Fiber concrete cylinder 1% | 15 | 30 | 5 |
| Fiber concrete cylinder 2% | 15 | 30 | 5 |
| **Total** | | | **15** |

b. Flexural strength test (15 x 15 x 60 cm)

**Table 2.** Specimen of Flexural Strength Test

| Specimen | Length (l) cm | Width (b) cm | Height (h) cm | Sample |
|---|---|---|---|---|
| Fiber concrete beam 0% | 60 | 15 | 15 | 5 |
| Fiber concrete beam 1% | 60 | 15 | 15 | 5 |
| Fiber concrete beam 2% | 60 | 15 | 15 | 5 |
| **Total** | | | | **15** |

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The workings used in this study is a test analysis of the mechanical properties of materials can be explained as follows:
To get the quality of concrete to be used then first made a mix design with the aim to obtain the composition of water, cement, sand, gravel, and chicken feather waste fiber with the quality of concrete planned $fc'$ = 20 Mpa.

According to SNI 03-1974-2011, compressive strength is determined by the highest compressive stress ($fc'$) achieved by 28-day-old specimen due to compressive load during the experiment. The magnitude of the compressive strength can be calculated by the equation:

$$f'_c = \frac{P}{A} \tag{1}$$

with P is the load received concrete (N) and A is the cross-sectional area (mm$^2$).
The flexural strength is the ability of concrete blocks placed on two placements to withstand forces in the perpendicular direction of the axis of the specimen, which is given to him until the specimen is failure which is expressed in mega pascal units (MPa) force of each unit of area (SNI 03-4431-2011).

$$\delta_1 = \frac{PL}{bh^2} \tag{2}$$

Equation 3.2 is used when a failure plane is located in the central area (an area of 1/3 of the distance of the center of the span). But if the failure plane is outside the center point, and the distance between the center point and the failure point is less than 5% of the distance between the laying points then the flexural strength is calculated by the following equation (SNI 03-4431-2011).

$$\delta_1 = \frac{Pa}{bh^2} \tag{3}$$

where:
$\delta_1$ = flexural strength of concrete (MPa)
$P$ = maximum load taken by the specimen (kN)
$L$ = supported length (mm)
$a$ = the distance between the line of fracture and the nearest support, measured on the center line of the tensile side of the specimen (mm)
$b$ = width of the beam (mm)
$h$ = height of the beam (mm)

The flexural strength test scheme with 2 seeding points is as follows SNI 03-4431-2011 can be seen in Figure 2.

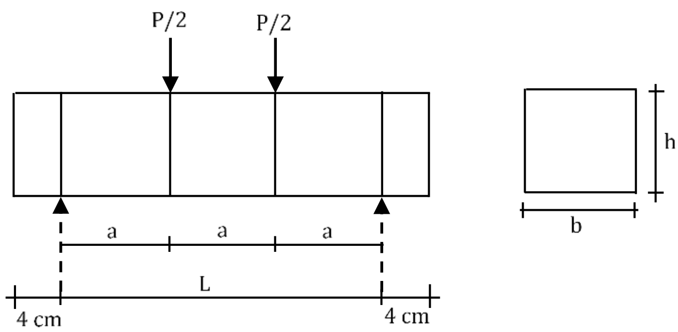


**Figure 2.** Flexural Strength Testing Scheme

**Research Flow Chart**

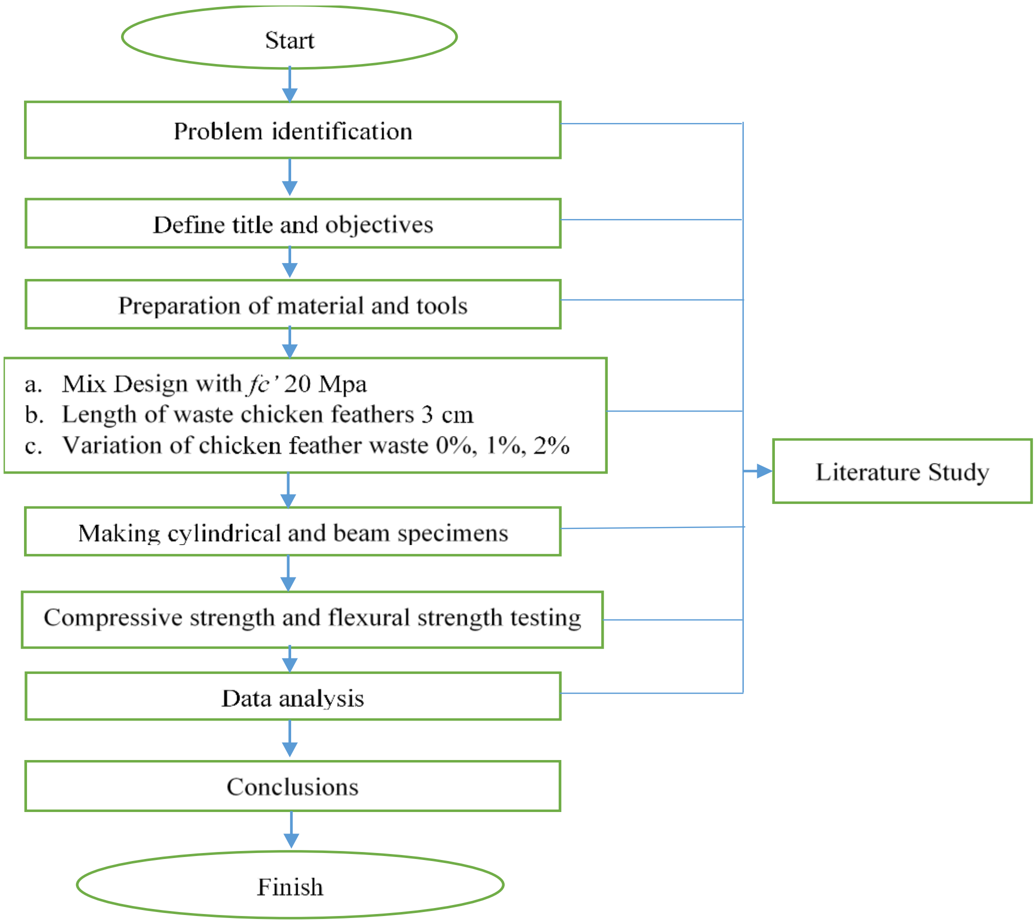


**Figure 3.** Research Flow Chart

## RESULTS AND DISCUSSION

### Results

Concrete specimens are made with additional waste fibers of chicken feathers by 0%, 1%, and 2% of the concrete volume. Each specimen is made as many as 5 samples. Concrete performed for testing is concrete with a lifespan of 28 days. As for the making of specimen and testing of concrete specimens can be seen in the following figure.

**Figure 4.** Concrete Testing in the Laboratory

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Testing of the cylinder compressive strength is performed using the compression machine. The results of compressive strength test can be seen in Table 3.

**Table 3.** Cylinder Compressive Strength Test Result

| Specimen | Chicken Feather Waste Concrete | Compressive Strength (kg/cm$^2$) | Average Compressive Strength (kg/cm$^2$) |
|---|---|---|---|
| 1 | 0% | 190.85 | 208.78 |
| 2 | 0% | 201.34 | |
| 3 | 0% | 202.16 | |
| 4 | 0% | 224.78 | |
| 5 | 0% | 224.78 | |
| 6 | 1% | 203.27 | 215.09 |
| 7 | 1% | 197.42 | |
| 8 | 1% | 208.65 | |
| 9 | 1% | 235.31 | |
| 10 | 1% | 230.84 | |
| 11 | 2% | 197.35 | 197.54 |
| 12 | 2% | 196.21 | |
| 13 | 2% | 208.65 | |
| 14 | 2% | 200.15 | |
| 15 | 2% | 185.34 | |

(Source: Test Results for January 2021)

The beam-shaped specimens are tested to find out how the flexural strength of its concrete beam. Concrete beam specimens are tested using Hydraulic Concrete Beam. The results of the testing of flexural strength concrete beam can be seen in Table 4.

**Table 4.** Concrete Beam Flexural Strength Test Result

| Specimen | Chicken Feather Waste Concrete | Flexural Strength (kg/cm$^2$) | Average Flexural Strength (kg/cm$^2$) |
|---|---|---|---|
| 1 | 0% | 20.00 | 24.00 |
| 2 | 0% | 21.33 | |
| 3 | 0% | 21.33 | |
| 4 | 0% | 25.33 | |
| 5 | 0% | 32.00 | |
| **Specimen** | **Chicken Feather Waste Concrete** | **Flexural Strength (kg/cm$^2$)** | **Average Flexural Strength (kg/cm$^2$)** |
| 6 | 1% | 21.33 | 23,03 |
| 7 | 1% | 22.00 | |
| 8 | 1% | 22.67 | |
| 9 | 1% | 23.84 | |
| 10 | 1% | 25.33 | |
| 11 | 2% | 19.67 | 21,08 |
| 12 | 2% | 24.67 | |
| 13 | 2% | 19.33 | |
| 14 | 2% | 21.05 | |
| 15 | 2% | 20.67 | |

(Source: Test Results for January 2021)

**Discussion**

From the results of this study, normal concrete (fiber 0%) at the age of concrete 28 days has an average compressive strength of 208.78 kg/cm$^2$, with the lowest and highest compressive strength were 190.85 kg/cm$^2$ and 224.78 kg/cm$^2$, respectively. The addition of chicken feather waste fiber by 1% has an average compressive strength of 215.09 kg/cm$^2$, experienced an increase in compressive strength of normal concrete. And in addition to chicken feather waste by 2% has an average compressive strength of 197.54 kg/cm$^2$, with the lowest compressive strength is 185.34 kg/cm$^2$. The addition of 2% chicken feather waste resulted in a decrease in the compressive strength of concrete against normal conditions and 1% fiber concrete. The comparison of the average of compressive strength of concrete for 0%, 1%, 2% fiber can be seen in Table 5 and Figure 5.

**Table 5.** Average Compressive Strength Concrete

| Specimen | Chicken Feather Waste Concrete | Average Compressive Strength (kg/cm$^2$) |
|---|---|---|
| 1 | 0% | 208.78 |
| 2 | 1% | 215.09 |
| 3 | 2% | 197.54 |

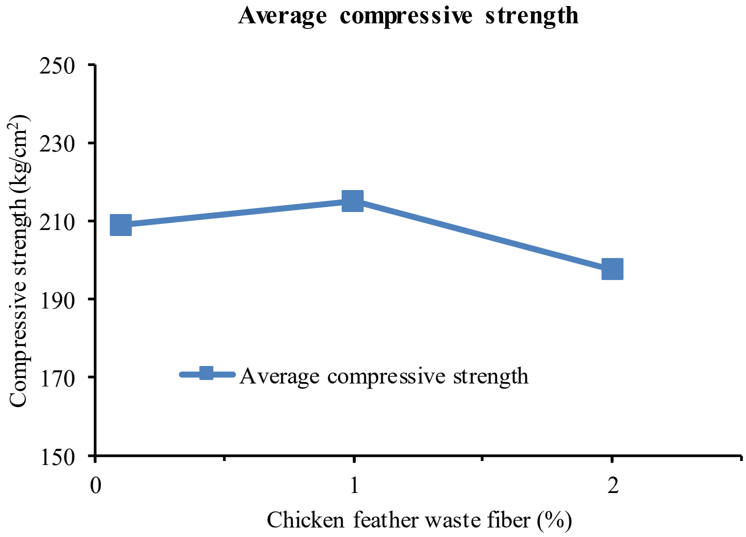


**Figure 5.** Average Compressive Strength with Chicken Feather Fiber 0%, 1% and 2%

From Figure 5 it can be seen that with the addition of chicken feathers 1% of the concrete composition can increase the value of strong press concrete from the normal concrete press force. However, on the addition of chicken feathers of 2% the composition of concrete resulted in a decrease in the compressive strength from normal concrete and concrete with a mixture of 1% chicken feathers. This is because the characteristics of the chicken feathers that exceed the optimal in the concrete mixture can reduce the compressive strength.

Furthermore, based on Table 4, for the average flexural strength of normal concrete (fiber 0%) at the age of concrete 28 days of 24.00 kg/cm$^2$, with the lowest and highest flexural strength were 20.00 kg/cm$^2$ and 24.00 kg/cm$^2$, respectively. The addition of 1% of chicken feather waste fiber has an average flexural strength of 23.03 kg/cm$^2$. And the addition of chicken feather waste by 2% has an average flexural strength of 21.08 kg/cm$^2$, with the lowest flexural strength is 19.33 kg/cm$^2$. The addition of the 2% chicken feather waste resulted in a decrease in the flexural strength of the concrete against normal and 1% fiber concrete conditions. This can be seen in Table 6 and Figure 6.

**Table 6.** Average Flexural Strength Concrete

| Specimen | Chicken Feather Waste Concrete | Average Flexural Strength (kg/cm$^2$) |
|---|---|---|
| 1 | 0% | 24.00 |
| 2 | 1% | 23.03 |
| 3 | 2% | 21.08 |

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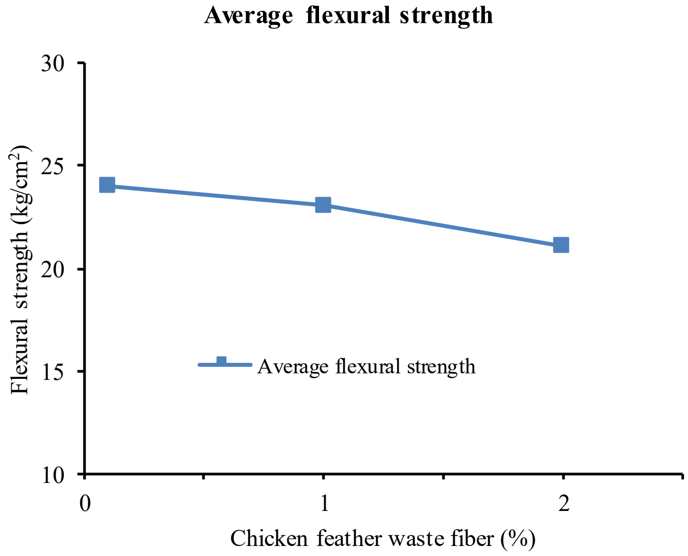


**Figure 6.** Average Flexural Strength Concrete Fibers Chicken Feathers 0%, 1% and 2%

## CONCLUSION

Based on the research and discussion, it can be concluded that concrete with the addition of chicken feather waste fiber by 1% at the age of concrete 28 days has an average compressive strength of 215.09 kg/cm$^2$ and has an average flexural strength of 23.03 kg/cm$^2$. While concrete with the addition of chicken feather waste by 2% at the age of concrete 28 days has an average compressive strength of 197.54 kg/cm$^2$ and has an average flexural strength of 21.08 kg/cm$^2$. With the addition of chicken feather waste by 1% concrete has a strong press rise from normal concrete. Whereas the addition of 2% chicken feathers resulted in decrease in the compressive strength of normal concrete and concrete with a mixture of chicken feathers 1%. It can be seen that, mixing 1% chicken feathers on concrete is the optimum condition in concrete compressive strength. On the other hand, the addition of chicken feathers up to 2% also causes a decrease in the flexural strength of the concrete. Thus, the greater the percentage of chicken feathers added to the concrete, if it reaches its optimum level in the mixture of 1% it will experience a decrease in the compressive strength. As for the flexural strength, the addition of chicken feathers as fiber does not have much effect on the flexural strength of concrete bending which precisely tends to decrease. It is influenced by the characteristics of chicken feathers that are difficult to bind with concrete beside chicken feathers easily absorb water, so concrete takes longer in drying after concrete maintenance.

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