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# Effect of Stone Ash Mixture and Coconut Fiber on Concreate Compressive Strenght

Mardiaman
*Tama Jagakarsa University, Indonesia*

**Abstract:** The composition of the concrete mixture determines the compressive strength. Concrete mixtures generally consist of cement, water, coarse aggregates, fine aggregates, and concrete drugs. In this study, it will be tried to mix stone ash and coconut fibers. The purpose of this study is to find out the concrete compressive strength with add stone ash and coconut fibers to normal concrete. Data was collected through laboratory tests by carrying out an additional mixture of stone ash and coconut fibers. There were six types of specimens produced which were measured for 7, 14, 21, and 28 days. Variation of specimens 1) normal concrete, 2) normal concrete + stone ash, 3) normal concrete + coconut fiber (1.5%), 4) normal concrete + stone ash and coconut fiber (1.5%), 5) normal concrete + stone ash and 1% coconut fiber, 6) normal concrete + 1% coconut fiber. From the results of testing the concrete compressive strength was obtained 455 kg/cm$^2$ for the age of concrete for 28 days with a mixture of normal concrete + stone ash.

**Keywords:** stone ash, coconut fiber, compressive strength

## 1. Introduction

The compressive strength of concrete is influenced by several factors. The composition of the mixture of concrete materials determines the compressive strength. Concrete is a mixture consists of cement, fine aggregate, coarse aggregate, and water. On a certain kind of concrete, it can be added by other materials, function as a kind of medicine for concrete. In the mixture of light concrete, the different percentage of cement is directly proportional to compressive strength. The basic material condition of the concrete constituents will affect the compressive strength produced [1].

Waste materials can also be used to get a certain level of concrete compressive strength. A 35 MPA quality concrete is done by utilizing building debris waste as a mixing material for the concrete [2]. The mix of palm fiber can be used to determine the effect of compressive strength and the changing of concrete weight [3]. The use of varied material results in different concrete qualities. There are concrete that mixed with bamboo fibers [4], plastics fiber [5], burnt coconut shell [6], flying ashes [7], coconut coir and Polyester resins [8], palm oil filtering leftover [9], broken glasses [10], pure sugar and ash charcoal briket [11], coal waste [12], newspaper waste, burnt sugar cane leftover [13], copper slag [14], palm fiber [15], the debris of bricks and fiber [16], bandrat fiber and paddy rice husk ashes [17].

Coconut coir as a mixing material for concrete has a very bright future. The use of the abundant coconut skin fiber leftover as the mixing material can increase the quality of concrete because it can perfectly bond the concrete mix and absorb water to accelerate the binding so that it can dry faster and stronger.

In addition to coconut coir, concrete mixture can be added by stone ashes. Stone ashes are very useful in the making of paving blocks, pressed bricks or the layering of asphalt on the road. Stone ashes today are like waste

**Corresponding author:** Mardiaman, Dr.; research areas/interests: environment and construction management. E-mail: mardi240967@gmail.com.

from the rock breaking process which must be utilized for concrete mix, asphalt mixture, or other purposes.

The strength, durability, and nature of concrete depend on the nature and base material, ratio of the materials, method of stirring, method of working during the pouring of the concrete mixture, method of compaction, and method of treatment during the hardening and bonding process.

Stone ash is a by-product of the stone-breaking industry which is not insignificant so that the stone ash in the stone crusher becomes a waste material that is still considered how to make use of it.

Stone ash serves as an alternative replacing sand. The advantages of stone ash compared to sand is that stone ashes' grain size is as small as dust. Its size is quite evenly distributed in all parts, so no sifting is needed. The second is stone ashes have so sharp in texture that strongly bonds inside the concrete. The concrete mortar added by stone ashes grain neither should be too condense nor too watery that can be seen from its slum value (Table 1).

Cement binds aggregate grains forming a solid mass and fills air cavities between aggregate grains. The physical characteristics of good quality of types of cement are the fineness and bonding time that consisting of initial bonding time which is more than 60 minutes and final binding time which is more than 480 minutes. There are some types of cement: white Portland cement, Pozzolan Portland cement, and Portland cement (Table 2).

Hydraulic Portland Pozzolan Cement consists of a homogeneous mixture of Portland cement with fine pozzolan where the pozzolan content is 6% to 40% mass of the Portland pozzolan cement.

**Table 1 Value of lump for a variety of concrete work.**

| No | Description | Slump (cm) | |
|---|---|---|---|
| | | max | min |
| 1 | Plate wall foundation and reinforced plate foundation. | 12.5 | 5 |
| 2 | Plain plate foundation, caisson, and substructure construction. | 9 | 2.5 |
| 3 | Plates, beams, columns, and walls. | 15 | 7.5 |
| 4 | Road hardiness | 7.5 | 5 |
| 5 | Mass concreting | 7.5 | 2.5 |

**Table 2 Chemical and physical requirements of white Portland cement.**

| No | Kind of tests | Unity | Requirements |
|---|---|---|---|
| 1 | MgO | % | 5.0 ≥ |
| 2 | $SO_3$ | % | 3.5 ≥ |
| 3 | $Fe_2O_3$ | % | 0.4 ≥ |
| 4 | Missing incandescent | % | 5.0 ≥ |
| 5 | insoluble parts | % | 3.0 ≥ |
| 6 | Alkali as $Na_2O$ | % | 0.6 ≥ |

### *1.1 Portland Cement*

Hydraulic cement is produced by grinding the Portland cement slag and milling together with additives in the form of one or more crystalline forms of calcium sulfate compounds and may be added with other additives.

1.1.1 Compressive Strength

One of the compressive strength of cement is determined by the cement component, calcium silicate. In the development of the initial compressive strength (28 days), it is dominated by hydration of $C_3S$ and supported by $C_3A$. C2S and C4AF will contribute to compressive strength for a longer lifespan.

### *1.2 Setting Time*

The mixing between cement and water will form a dough that is chewy and can be shaped (workable) then finally can harden in some period. In some time, this paste remains soft but stiffer so that can no longer be formed into shapes. Furthermore, the paste becomes stiffer and becomes solid and brittle (rigid). This process continues until the cement paste becomes harder and stronger which is called hardening.

1.2.1 Coarse Aggregate

Coarse aggregate usually called gravel is a result of natural disintegration from artificial or broken stone obtained from the stone-breaking industry, with grain sizes of 4.76 to 150 mm.

1.2.2 Fine Aggregate

Fine aggregate for concrete can be in the form of natural sand as a result of the natural disintegration of rocks or artificial sand produced by the stone breaking tool. This aggregate measuring from 0.063 to 4.76 mm includes coarse and fine sand.

1.2.3 Medicine (Admixture)

Admixture is a material other than water, cement, and aggregate added to concrete or mortar before or during stirring. The admixture is used to modify concrete properties and characteristics. The objectives of adding the admixture among others are: 1) to improve concrete workability. 2) to regulate the cement water factor on fresh concrete, 3). To reduce the use of cement, 4) to prevent the occurrence of segregation and bleeding, 5) to adjust the binding time of the concrete stirring, 6) to increase the strength of hard concrete. 7) To improve the water-resistant properties of hard concrete, 8) improve the durable properties of hard concrete including resistance to chemicals, resistance to friction, or more.

1.2.4 Admixture Types

According to ASTM C.494, the admixture is divided into seven types:

1) Type A: Water Reducing Admixture (WRA). Serves to reduce the use of stirring the water to produce concrete with a certain consistency.

2) Type B: Retarding Admixture is an additional material that serves to slow down the process of binding time for concrete. Usually used during hot weather conditions, extending the time for compaction, transportation, and casting.

3) Type C: Accelerating admixtures. Type of added material that serves to accelerate the binding process and the development of the initial strength of concrete.

4) Type D: Water reducing and retarding admixture. The dual function is to reduce the amount of stirring water needed in the concrete but still obtain a stir with a certain consistency while slowing the initial bonding process and hardening of the concrete.

5) Type E: Water reducing and accelerating admixture, the dual function is to reduce the amount of stirring water needed in the concrete but still obtain a stir with a certain consistency while accelerating the process of initial binding and hardening of concrete.

6) Type F: Water reducing, High range Admixture. serves to reduce the amount of mixing water needed to produce concrete with a certain consistency, as much as 12% or more.

7) Type G: Water reducing, High Range retarding admixtures function to reduce the amount of mixing water needed to produce concrete with a certain consistency, as much as 12% or more while inhibiting the binding and hardening of concrete.

Another type of added material commonly used is the air bubble forming agent (Air Entraining Agent/AEA). There are two types of AEA: 1) detergent and 2) non-detergent.

In general, detergent AEA is detergent which is an active substance on the surface. This substance is usually in the form of organic substances as soap raw material, so that when stirred with water it will be foamed and spread into the concrete mix. These bubbles are located between the grains of cement and aggregate which function as a ball rolling so that the concrete mix becomes easier to stir. The addition of AEA makes concrete has small shrinkage properties and more waterproof. The material commonly used to make AEA is resin vinyl which is an abiotic acid compound or commonly referred to as soda.

Non-detergent, usually in the form of fine aluminum powder. This powder when mixed with water in the concrete will react to form hydrogen gas air bubbles. A stabilizer (Sodium Stearate) is also used so that the bubbles can spread evenly and firmly.

### *1.5 Coconut Skin Fiber (Coir)*

Coconut coir is a fairly large portion of the coconut fruit, which is 35% of the overall weight of the fruit. Coconut coir consists of fibers and corks that connect one fiber with another fiber. Fiber is a valuable part of coir. Each coconut contains 525 grams of fiber (75%) and a cork of 175 grams (25%). One coconut fruit produces 0.4 kg of coir which contains 30% fiber. The chemical composition of coconut coir consists of cellulose, lignin, pyroligneous acid, gas, charcoal, tar, tannin, and potassium. The chemical composition of coconut coir consists of cellulose, lignin, pyroligneous acid, gas, charcoal, tannin, and potassium

From the physical appearance, coconut fiber consists of 1) Coarse and fine, but not rigid fibers, 2) Contains wood elements such as lignin, tannin, and waxes. This fiber quality is determined by color and thickness.

1.5.1 Stone Ashes

Stone ash is a construction material that originated from the side process of the cement and broken stone industry. Material is included in the category of artificial aggregates that are needed as a mixture in the process of asphalting and sand replacement. Besides, the manufactures of culverts and brick presses also use this material as the main composition. No different from its name, this material has a gray form with a texture in the form of granules. New grains split, gravel, sand, or material others have a very small size. Compared to sandstone, this rock has a better binding capacity. In conditions exposed to water, sand will be more easily decomposed, meanwhile when the water pressure, rock ash will be stronger binding and hardening. This good binding ability is due to its very sharp texture. The factor causing this sharp texture is none other than its origin which is a byproduct of the process of breaking the stone which is also sharp. Therefore, this material is also very good if used as supporting material in concrete mixtures.

To achieve results or to determine the effect of the use of the material, nowadays, the tests for the addition of certain materials is being carried out. The material is added to concrete mixes for various purposes, including reducing the use of cement, fine aggregates and coarse aggregates. How to use it also varies, as a substitute for part of the aggregate or as an addition to the mixture to reduce aggregate use.

1.5.2 The Characteristics of Fresh Concrete

(1) Fresh Concrete Velocity

Factors that affect the freshness of fresh concrete:

1) Amount of water

The more water that is used the more dilutes the fresh concrete. The more amount of water the fastest value increases, and then the concrete compressive strength decreases

2) Amount of paste (cement and water)

The more paste added, the more watery the mix is. The addition of paste is done to make the mixture thinner, but the fas value remains so that the compressive strength of the concrete doesn't change

3) Aggregate gradation (a mixture of fine and coarse aggregates)

If the gradation is according to the standard, it will be easy to do. Gradations need to be calculated so that the mixed aggregates meet the standards.

4) Aggregate grain form

Rounded grains will appear thinner.

5) Aggregate maximum grain size

The large maximum grain will appear thinner.

1.5.3Aggregate Separation

The separation of aggregates from the concrete mix is called segregation. Aggregate segregation can be reduced by 1) Increase the amount of Portland cement; 2) Reducing the amount of water; 3) Reducing the maximum grain size; and 4) Height falls when pouring is less than 1 meter

*1.6 Water Separation*

There are tendencies of mixed water in fresh concrete to rise to the surface; this event is called "bleeding". Bleeding is a very unwanted situation because the water rises to the top while carrying cement and fine beads, then when hardened they will appear as a thin layer called "laitance". The laitance layer will reduce the bond between the concrete underneath and the concrete above it. The separation of water can be reduced by:

Increasing cement, using not too much water, or using more fine grains.

Some characteristics of fresh concrete must be watched out for:

1.6.1The Easiness of Workability

This character is a measurement of the easiness level of the mixture to be stirred, transported, poured and solidified. It is influenced by: Sifat ini merupakan ukuran dari tingkat kemudahan adukan beton untuk diaduk, diangkut, dituang dan dipadatkan. Sifat kemudahan dikerjakan pada beton segar dipengaruhi oleh:

(1) The amount of water used in the mixing concrete mixture. The more water is used; the easier fresh concrete is to be worked with but a large amount of water can reduce the compressive strength of concrete.

(2) The addition of cement to the mixture. The more cement is used; the easier fresh concrete is to be worked with.

(3) The fine and coarse aggregate gradations. If the aggregate used has suitable gradation according to the requirements, then the concrete mix will be easy to be worked with.

(4) The aggregate granules. The round aggregate granules will make it easier to work on concrete.

(5) The use of mineral admixture and added mineral ingredients. The level of easiness of workability is closely related to the elasticity of the concrete. To measure it, slump testing is performed. The great number of slumps means that the mixture is watery and this means that the concrete is easier to work with. Slump values range from 5-120 cm. For fresh concrete, segregation and cohesiveness of the mixture must be avoided. Segregation occurs because the concrete lacks fine grains, cement grains are coarse or the mixture is watery. The cohesiveness of concrete is caused by lack of cement, lack of sand, lack of water, and a large arrangement of aggregate grains. To avoid the segregation and in the cohesiveness of the mixture, improving the composition of the concrete mixture is needed, such as improving the water content, the sand content, the maximum size of aggregate grains, and adding the number of fine grains/fillers.

1.6.2 Content Weight

The content weight of concrete functions as corrections to concrete mixture composition if the planning results are different from the implementation. The correction rate is obtained from the comparison between the weight of the concrete contents of the planning and the concrete content weight of the implementation. This is function as the conversion from weight units to volume units and as the correction for the surplus or the shortage of materials when the concrete is being made that can affect the overall work volumes.

*1.7 Binding Time*

The binding time of concrete is the time needed for concrete to harden, starting from a plastic state to a rigid (hard) shape.

1.7.1 The Characteristics of Hard Concrete

The characteristics of hardened concrete have an important meaning during its period of usage. There are compressive strength and tensile strength.

The mechanical behavior of hard concrete is the ability of concrete in carrying the burden on building structures. The good performance of hard concrete is shown by the high compressive strength of concrete, better tensile strength, more ductile behavior, water, and airtightness, resistance to sulfate and chloride, low shrinkage, and long-term durability.

The factors that influence the strength of concrete, according to the background of the cause, are divided into three groups: a) Characteristics and proportions of concrete mixture; b) Maintenance conditions; c) Testing factors.

a) Characteristics and proportions of a concrete mixture.

How to decide the proportion of the concrete mix is the first thing to do in the process of designing the mixture to achieve the desired quality. Though we have to admit that the influence of each concrete shaper component on its strength is interdependent. The dominant influence needs to be taken into consideration

b) Water/cement ratio.

c) Laboratory test shows that an increase in the water/ cement ratio of 0.35 to 0.65 will reduce the strength of concrete almost linearly to 50% (under other conditions of the same mixture).

Many studies had been conducted using waste materials which not only reduced the waste for the environment but also minimalized the cost. That's why researchers must involve the stone ash and coconut fiber in their researches to discover how much the compressive strength is produced.

## 2. Materials and Methods

The study was conducted by conducting some experiments in a laboratory. There are six concrete specimens, named concrete A, B, C, D, E, and F. Their strengths are measured every 7, 14, 21, and 28 days. The mixing material is 1) Portland cement; 2) coarse aggregate passed a 38.1 mm sieve and held up to 4.76 mm with fineness modulus of 5.4 to 7.5; 3) Water sand, we used PDAMs where the water physical presence is clear, colorless, odorless, tasteless and dirtless; 4) coconut fiber, and 5) stone ash.

### *2.1 Material and Methods*

The number of samples is 24. We made 4 test speciments of four mixture variations: 1) normal concrete; 2) normal concrete + stone ash; 3) normal concrete + 1.5% coconut fiber; 4) normal concrete + stone ash and 1.5% coconut fiber; 5) Normal concrete + stone ash and 1% coconut fiber; and 6) Normal concrete + 1% coconut fiber.

First, pour 70% of water with the medicine (Admix). Then, add the coarse aggregate, followed by the fine aggregate, stir evenly. Next, pour the cement, stir until the homogeneous level is reached. After that, pour the rest of 30% water with the additive material such as stone ashes into the molding machine, stir thoroughly for another minute until homogeneous.

After the homogeneous dough mixed evenly, pour it into the wagon for the thickness to be measured by using the slump test method from the abrams-harder cone. After finishing the measurement, pour the concrete mixture into a cylindrical molding of 15 cm diameter and 30 cm high in three stages. Filled 1/3 part of the mold for every stage, solidified using an iron bore.

After 24 hours of concrete life, the cylinder mold is opened and concrete treatment is carried out by immersing it in the soaking tub until the planned time for testing.

According to PBI 171 NI 2 (Indonesian Reinforced Concrete Regulation), Slump measurements are carried out using tools as

(a) Cone abrams: 1) cut cone, 2) upper diameter is 10 cm, bottom diameter is 20 cm, Height is 30 cm.

(b) Awl iron rod: 1) 16 mm in diameter, 2) 60 cm long, 3) Rounded tip.

(c) Base: flat, does not absorb water.

According to SNI 1972-2008 Measurement of slumps is done with the following tools:

(a) Cone abrams: 1) Cone cone, with top and bottom open, 2) Upper diameter 102 mm, 3) Bottom diameter 203 mm, 4) Height 305 mm and 5) Plate thickness of 1.5 mm.

(b) Piercing iron bars: 1) Diameter 16 mm, 2) Length 60 cm, 3) has one or both ends of a half-ball round shape with a diameter of 16 mm,

(c) Base: Flat, in humid conditions, does not absorb water and is rigid.

Before doing the compressive strength test, we weigh the test object. Concrete compressive strength testing is done by using an electric compress machine with a capacity of 200 tons which is moved manually.

Concrete compressive strength is calculated using:

$$\text{Concrete compressive strength} = P/A \qquad (1)$$

P = axial compressive force

A = cylinder cross-sectional area = 17,671 $cm^2$

**Fig. 1 Concrete sample testing.**

## 3. Results and Discussion

Based on the measurement results, the slump value before and after adding coconut fibers has the highest value in normal concrete + coconut fibers 1.5% with a value of 14 before and 7 at after.

The results of testing the slump value for each test concrete can be seen in Table 3.

From Table 3 it can be concluded that with the use of stone ash and coconut fibers in a concrete mixture, the value of slump tends to decrease. This is caused by the addition of rock ash and coconut fiber which is high,

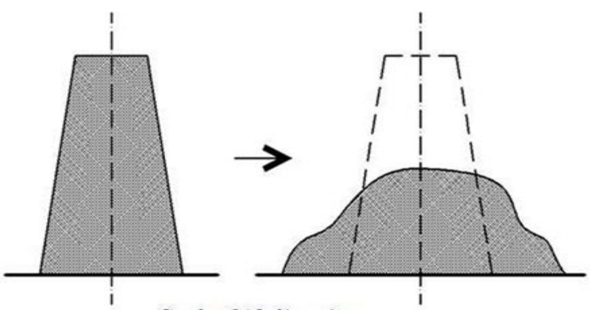


**Fig. 2 Shear slump.**

**Table 3 Slump values in concrete.**

| Name | Concrete mixture | The value of slump before adding fiber | The value of slump after adding coconut fiber |
|---|---|---|---|
| A | normal concrete | 14 | - |
| B | Normal concrete + stone ash | 13.5 | - |
| C | Normal concrete + coconut fibers 1.5% | 14 | 7 |
| D | Normal concrete + stone ash & coconut fibers 1.5% | 13.5 | 6 |
| E | Normal concrete + stone ash & coconut fiber 1% | 12.5 | 5,5 |
| F | Normal concrete + coconut fiber 1% | 12 | 5 |

resulting in decreased air volume and water-cement factor. This is due to the nature of stone ash and coconut fibers which have very high water absorption.

### *3.1 Concrete Cylinder Compressive Strength*

The compressive strength of concrete is tested at 7 days old, 14 days old, 21 days old, and 28 days old. That is to get the optimum compressive strength results using additives rock ash and coconut fibers. Concrete compressive strengths for concrete A, B, C, D, E, and F with ages 7, 14, 21, and 28 days are presented in Table 4.

From the results of testing concrete samples aged 7 days to 28 days, it can be seen that obtained strength in the addition of coconut fibers has decreased. The decrease in compressive strength on the addition of stone ash and coconut fibers is caused by the fiber that is inserted into the concrete mix because it reduces the volume of concrete that should be filled by cement paste.

Seeing the results, the compressive strength of concrete in Table 4, the concrete produced falls into class 2 and 3 categories.

**Table 4 Compressive strength of concrete cylinders.**

| Beton | Symbol | Age day | The average weight of cylinder (kg) | Conpressive strenght (kg/cm²) | % compressive strenght |
|---|---|---|---|---|---|
| A | T-1 | 7 | 12.3 | 305 | 70.65 |
| A | T-1 | 14 | 12.2 | 375 | 86.8 |
| A | T-1 | 21 | 12.5 | 410 | 94.9 |
| A | T-1 | 28 i | 12.4 | 450 | 104.2 |
| B | T-2 | 7 | 12.4 | 310 | 71.0 |
| B | T-2 | 14 | 12.0 | 380 | 88.0 |
| B | T-2 | 21 | 12.3 | 420 | 97.3 |
| B | T-2 | 28 | 12.3 | 455 | 105.4 |
| C | T-3 | 7 | 12.0 | 160 | 37.0 |
| C | T-3 | 14 | 12.1 | 250 | 57.9 |
| C | T-3 | 21 | 12.1 | 310 | 71.8 |
| C | T-3 | 28 | 12.0 | 370 | 85.7 |
| D | T-4 | 7 | 12.1 | 170 | 39.3 |
| D | T-4 | 14 | 12.0 | 265 | 61.4 |
| D | T-4 | 21 | 12.0 | 330 | 76.4 |
| D | T-4 | 28 | 12.2 | 380 | 88.0 |
| E | T-5 | 7 | 12.0 | 270 | 62.5 |
| E | T-5 | 14 | 12.0 | 340 | 78.8 |
| E | T-5 | 21 | 12.1 | 390 | 90.4 |
| E | T-5 | 28 | 12.1 | 430 | 99.6 |
| F | T-6 | 7 | 12.2 | 280 | 64.9 |
| F | T-6 | 14 | 12.0 | 355 | 82.2 |
| F | T-6 | 21 | 12.0 | 400 | 92.7 |
| F | T-6 | 28 | 12.1 | 440 | 101.9 |

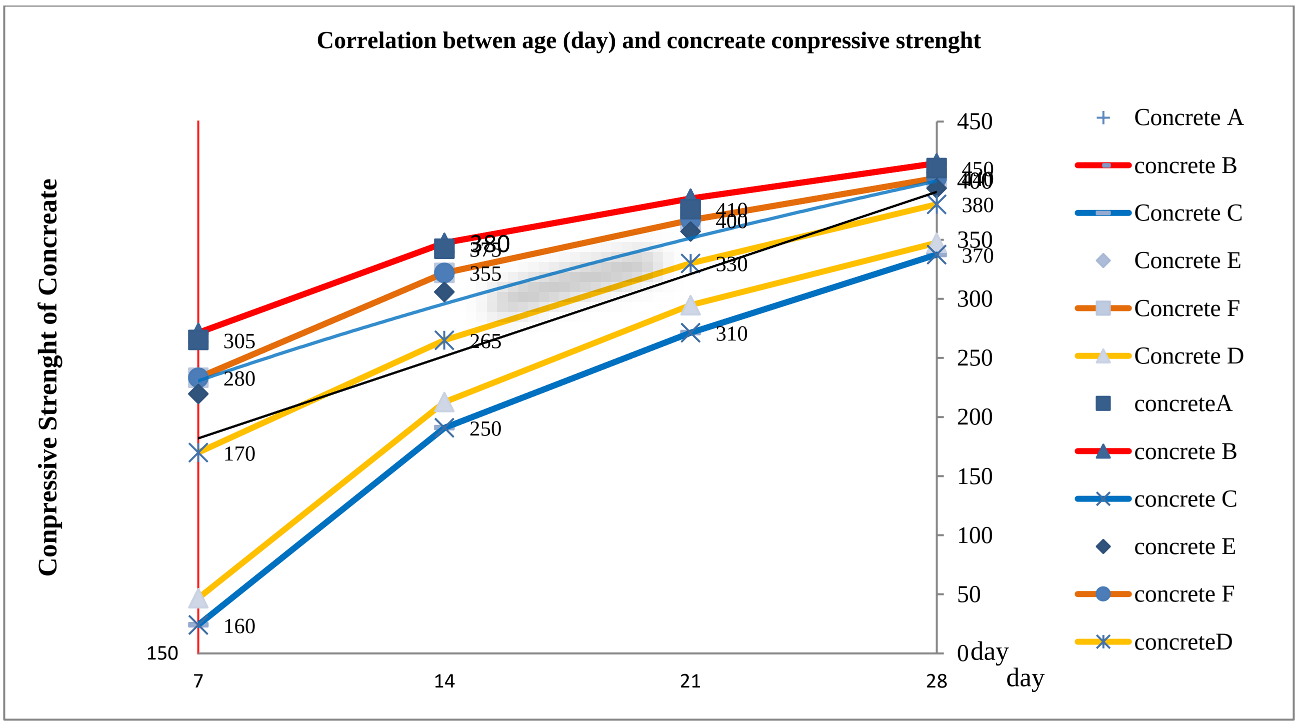


**Fig. 2 Relationship between days and concrete compressive strength.**

### *3.2 Compressive Strength Test Patterns*

The test on the strengthening of compressive strength in concrete found an interesting case to be observed, which is the crack pattern on the cylindrical specimen as shown in Fig. 3. The crack pattern that occurred in the compressive strength test of the concrete cylinder was the cone and shear crack pattern.

In the beginning, there is an uneven surface in some cylindrical concrete specimens. This is due to the shrinkage that occurs in the concrete during the binding process. So the surface decreases from its original state. Therefore, to get maximum results on the test specimen, before testing the specimen, it must be stamped to get a flat surface. Concrete B specimens which were 28 days old got 105.4% so that the specimens were included in the Indonesian concrete standardization. Besides concrete A and F, 28 days old are also included in the Indonesian concrete standard with values of 104.2% and 101.9% each.

**Fig. 3 Crack pattern of concreate cylinder test.**

## 4. Conclusion

1) The use of stone ash and coconut fibers in concrete mixtures with a variation of 1% of fine aggregate can reduce the value of slump.
2) The use of stone ash and coconut fibers in concrete mixtures with a variation of 1% of the fine aggregate of the concrete volume results in a decrease in compressive strength.

## 5. Suggestion

It is necessary to examine more of the use of stone ash and coconut fibers with a smaller percentage than that which has been carried out to find optimum levels of use of stone ash and coconut fibers at least close to the normal concrete compressive strength.

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