Alternative of stone ash as a sand replacement in fc '40 mpa quality concrete mixture on pressure stress

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Abstract. Stone ash is the result of breaking stone by using a stone crusher. Stone ash is currently a by-product in the industry the amount of stone is not small. At present stone ash is not very salable for sale because the use in the construction industry is very little considering the use of sand as fine aggregate is still used for concrete mixtures. The method used in this study is a reduction in the amount of sand used in the concrete composition replaced with stone ash. Where the percentage of the use of stone ash is determined at 5%, 10%, 15% and 20% of the amount of sand, using concrete quality Fc '40 Mpa. From this study, it is known that the more mixed the ash, the lower the compressive strength. Each 5% increase in the proportion of rock ash mixture to the weight of sand results in a decrease in strength. For 0% of stone ashes produce Fc ' = 40.17 MPa; 5% of stone ash produces Fc ' = 39.37 MPa; 10% of stone ash produces Fc ' = 38.32 MPa; 15% of stone ash produces Fc ' = 37.38 MPa; 20% of rock ash produced Fc ' = 36.8 Mpa. From the research carried out the addition of rock ash more than 5% decreased the concrete compressive strength required because by using a mixture of 5% stone ash, the compressive strength of concrete only reached 39.37 Mpa.

1. Introduction
In the field of construction, the material that is often used is concrete. The use of concrete is the main choice because concrete is a basic material that is easily formed at a relatively cheap price compared to other construction. Concrete is a mixture of Portland cement, coarse aggregate, fine aggregate and water. Concrete hardening will occur immediately because of the bond between water and cement, where the mass of concrete will grow stronger with increasing age of concrete. In making concrete, the selection of materials used is very important, especially for obtaining concrete quality with special properties, which desired for certain purposes in the most economical way.

Along with the scarcity of sand raw materials, nowadays in some concrete construction works, sand is replaced with stone ash, stone ash is the result of processing broken stones using stone crusher. Stone ash is currently a by-product in the industry, the amount of which is not small. At present stone ash is not very salable for sale because the use in the construction industry is very little considering the use of sand as fine aggregate is still used for concrete mixes. For this reason, a normal concrete composition is tested by testing the compressive strength of concrete by using stone ash as a substitute for sand for concrete mixture.

According to [4] that the more mixture of rock ash, the lower the compressive strength. Every 20% increase in the proportion of rock ash mixture to the weight of sand results in a decrease in strength. For 0%
of stone ashes, $F_c' = 20.67$ MPa; 20% of stone ash produced $F_c' = 19.44$ MPa; 40% of stone ash produced $F_c' = 18.14$ MPa; 60% of stone ash produces $F_c' = 17.03$ MPa; 80% of stone ash produces $F_c' = 15.94$ MPa; 100% rock ash produces $F_c' = 15.01$ Mpa. From the research carried out the addition of rock ash more than 20% did not reach the concrete compressive strength required because by using a mixture of 20% stone ash, the compressive strength of the concrete only reached 19.44 Mpa. For this reason, it is necessary to test the compressive strength of the concrete with the composition of adding rock ash below 20% to the weight of sand as a substitute for sand, in order to make a better change in the compressive strength of the concrete mixture.

2. Literature Review

2.1 Cement
Cement is a solid, hard object with a strong compressive strength but weak to tensile, with its base material being: cement, fine aggregate (sand), coarse aggregate (gravel), water and other additives as admixed material (stone ash). Cement is an important bonding material and is widely used in physical construction around civil construction, compounds contained in mothballs cement (CaO), sandililate (SiO2), soilLi (Al2O3), seedsBesi (Fe2O3), magnesium (MgO), sulfur (SO3), soda or potash (Na2O + K2O). If added, cement water will become a cement paste. If added with fine aggregate, cement paste will become mortar and if combined with coarse aggregate into fresh concrete mixture which after hardening will become hard concrete. The function of cement is to bind aggregate granules until they form a period (solid and fill air cavities between aggregate grains. Cement is a very complex industrial product, with different mixtures and structures, cement can Concrete regulation 1989 (SKBI. 4,53,1989) division of cement portland into five types [9] those are:

a) Type I
Porcelain cement which in its use does not require special requirements such as other types, is used for public buildings that do not need to use special requirements.

b) Type II
Porcelain cement which is in use requires resistance to sulfate and moderate hydration heat. Used for construction of buildings and concrete which are continuously in contact with dirty water or ground water or for foundations that are retained in soil containing aggressive water (sulfate salts) and sewerage or buildings that are directly related to swamps.

c) Type III
Portland cement in its use requires high initial strength in the initial phase after binding occurs, this type of cement is used in areas with low temperatures, especially areas that have winter (winter season)

d) Type IV
Portland cement which in its use requires low hydration heat, is used for large jobs, such as weir work, large foundation or other large work

e) Type V
Porcelain cement which in its use requires high resistance to sulfate, is used for buildings related to seawater, industrial waste water, buildings affected by aggressive chemical gases or vapors and for buildings associated with high percentage of sulfuric groundwater.

2.2 Fine Aggregate
Fine aggregate (sand) is a natural mineral that functions as a filler in a concrete mixture that has a grain size of less than 5 mm or passes no. 4 filter and is stuck on filter no.200. Fine aggregate (sand) comes from the natural disintegration of rock breakers. Types of sand:

a) Excavated sand
   This class of sand is obtained directly from the ground surface or by digging it first. This sand is usually free of salt content

b) River Sand
   This sand is obtained directly from the river, which is generally fine-grained, rounded due to friction, less adhesion between granules due to strong grain. Because the grain size is small, it is good to use for plastering the walls as well as other necessities.

c) Sea Sand
   Sea sand is sand taken from the beach, the grain is smooth and round due to friction, this sand is the ugliest sand because it contains lots of salt. These salts absorb water from the air and this results in the sand always getting wet. Therefore, it is better for sea sand (beach) not to be used in concrete mixes.

2.3 Coarse Aggregate
Coarse aggregates come from natural disintegration of natural rocks or in the form of broken stones produced by stone breakers with a grain size of more than 5 mm or retained by no. 4 filter.

2.4 Water
Water is an important basic material for making concrete. Water is needed to react with cement and as a lubricant between aggregate grains to be easily worked and compacted. Water containing dangerous compounds contaminated with salt, oil, sugar, or other chemicals when used in concrete mixtures will reduce the quality of the concrete and can even change the properties of concrete.

Because cement paste is the result of a chemical reaction between cement and water, it is not the ratio of the amount of water to the total weight of the mixture that is important, but rather the ratio of water to cement or commonly called cement water ratio. Low water content causes hard to work concrete (not easy to flow), and high water content causes low concrete strength. Besides that the excess water will be together with cement moving the surface of the freshly poured fresh concrete and then become foam and form a thin layer known as laitance. This thin membrane will reduce adhesion between the concrete layer and is a weak connection area. If there is a mold leak, water with cement can also come out so there are small nests. Apart from the amount of water, the quality of water must also be maintained, the impurities contained in the water can cause the strength of the concrete and its durability to decrease, the effect on the concrete including the length of the initial bonding time.

2.5 Stone Ash
Stone ash is a building material which is the result of the process of breaking stone slabs that are used for concrete combinations. This aggregate is a mineral filler / filler that passes filter No. 200 size <0.075 mm, obtained from the by-product of a stone-breaking plant. Abu-stone stone can be said to have a lot of volume and is still in the development stage to reduce the use of sand in concrete mixes. Smooth. Stone Ash is often used as a side material as a combination of mortar or concrete. Stone ash is easy to obtain and can be considered cheap in terms of price.

High quality concrete testing with a strong pressure plan of 25 MPa, with cylindrical test material 15 x 30 cm, with a total sample of 10 samples, each variation using a mixture of Ash Bat as cement substitute material. Concrete testing was carried out at the age of 7 and 28 days with the results of the optimum pressure strength of 40 Mpa, namely the addition of Aboriginal Ash as much as 12% and at the age of 28 days [5]
2.6 Work Ability
This property is a measure of the level of ease of stirring to be complained, transported, poured and compacted. Comparison of the composition of the concrete constituent materials together affects the nature of workability (workability). Elements that affect the nature of ease of work include: addition of cement, gradation of sand and gravel mixtures, use of rounded relief items, and how to compact concrete.

2.7 Concrete Slump
Concrete slump experiments are a way to measure concrete stirredness, i.e., stir/liquid thickness which is useful in concrete work. The lower the slump value indicates that the mixture is getting thicker. Concrete slump checking is intended to determine the consistency of concrete and workability in accordance with the predetermined requirements shown in Figure 1, while the Test Slump values are in Table 1.

![Figure 1. Possibly Slump](image)

| Types                                                                 | Slump (mm) | Max | Min |
|-----------------------------------------------------------------------|------------|-----|-----|
| Walls, Plates, Foundations and Bones for Bones                       |            | 125 | 50  |
| The foundation of the palm is not boned, kaison and underground construction |            | 90  | 25  |
| Plate, beam, column and wall                                           |            | 150 | 75  |
| Pavement                                                              |            | 75  | 50  |
| Mass concretion                                                       |            | 75  | 25  |

Source: PBI 1971

3. Methodology
The research was carried out in the concrete laboratory of the Faculty of Engineering, University of Darul Ulum Jombang. Before making the test specimens for research on the "Alternative of Ash Stone as a Substitute of Sand in Fc 40 Mpa Concrete Mixture Against Workability and Compressive Strength", it is necessary to check the constituent material. The stages for conducting research in the laboratory are carried out in 7 stages, Figure 2.

1. Provision of concrete constituents
2. Material inspection
3. Mix Design
4. Making test specimens
5. Curing
6. Testing the compressive strength of concrete aged 7 days, 14 days, 21 days and 28 days
7. Analysis of Test Results

Figure 2. Research Flow Chart

4. Result

4.1 Concrete Mixture
The results of the proportion of concrete mix design $F_{c'} = 40$ MPa in 1.0 m$^3$ concrete are presented in Table 2 and Table 3.

**Table 2. Design of Normal Concrete Mixtures**

| Parameter                                                                 | Value          |
|---------------------------------------------------------------------------|----------------|
| Standard deviation ($s$)                                                  | Mpa            |
| Value-added ($m$)                                                         | 10 Mpa         |
| The concrete compressive strength required, at 28 days (from RKS) and fourth sheet ) $F_{c'}$ | 40 Mpa         |
| Average compressive strength ($F_{cr} = F_{c'} + m$)                       | 50 Mpa         |
| Cement type (Choices : normal or quickly hardens)                         | I              |
| Aggregate Type                                                            |                |
| **A type of fine aggregate (choose: natural / fractional)**                | Natural        |
| **B type of coarse aggregate (choose: natural / fraction)**               | Pieces         |
| Cement water factor (from attachment III and attachment IV)               | 0,39           |
| Slump value                                                               | 6 Cm           |
| Maximum size of aggregate grain                                           | 2 Cm           |
| Water requirement per cubic meter                                         | 189,9 Liter    |
| Cement requirements per cubic meter                                       | 487 Kg         |
| Type of fine aggregate (write: 1,2,3 or 4)                                | Zona 3         |
| The proportion of the weight of the fine aggregate to the mixture         | 35 %           |
| Mixed aggregate specific gravity                                          | 2,675          |
| Estimated weight of concrete per cubic meter                              | 2420 Kg        |
| Mixed aggregate needs per cubic meter of concrete                          | 1743,11 Kg     |
| Need for fine aggregate per cubic meter of concrete                        | 610,09 Kg      |
| The need for coarse aggregate per cubic meter of concrete                 | 1133,02 Kg     |
| Source : SK SNI 03-2847-2002                                              |                |

**Table 3. Result of proportion of concrete mixing design**

| Plan of Making Concrete | The need for concrete base material |
|-------------------------|-------------------------------------|
| Volume                  | Water                               |
| Weight                  | Cement                              |
|                          | Coarse                              |
|                          | fine aggregate                      |
| 1 m$^3$                 | 2420 kg                             |
|                          | 189,9 Ltr                           |
|                          | 487 kg                              |
|                          | 610,09 kg                           |
|                          | 113,02 kg                           |
| Stir                    | 12,83 kg                            |
|                          | 1,01 Ltr                            |
|                          | 2,58 kg                             |
|                          | 3,24 kg                             |
|                          | 6 kg                                |
4.2 Test Press Normal Concrete

The compressive strength of concrete is the amount of load per unit area, which causes the concrete test object to be destroyed when loaded with a certain compressive force, which is produced by the press machine. Testing of normal concrete compressive strength is carried out on cylindrical test objects using Compression Machine compressive strength testing machine. The test was carried out after the concrete reached the ages of 7, 14, 21 and 28 days. As for the results of testing the normal concrete compressive strength can be seen in table 4 and figure 3.

| Table 4. Normal Compressive Strength Results |
|---------------------------------------------|
| No  | (Mpa) | Days |
|-----|-------|------|
| 1   | 26,11 | 7    |
| 2   | 35,35 | 14   |
| 3   | 38,16 | 21   |
| 4   | 40,17 | 28   |

Figure 3. Normal Strength Compressive Graph

4.3 Concrete Press Test With Substitute Ash Stone

The compressive strength of concrete is the amount of load per unit area, which causes the concrete test object to be destroyed when loaded with a certain compressive force, which is produced by the press machine. Testing of concrete compressive strength with rock ash replacement material is carried out on the cylinder test object by using Compression Machine compressive strength testing machine. The test was carried out after the concrete reached the ages of 7, 14, 21 and 28 days. The results of testing the compressive strength of concrete with a substitute for rock ash can be seen in table 5 and figure 4.

| Table 5. Normal Compressive Strength Results |
|---------------------------------------------|
| No  | Stone Ash % | Mpa 7 Days | Mpa 14 Days | Mpa 21 Days | Mpa 28 Days |
|-----|-------------|------------|-------------|-------------|-------------|
| 1   | 5           | 25,59      | 34,64       | 37,40       | 38,37       |
| 2   | 10          | 24,91      | 33,73       | 36,41       | 38,32       |
| 3   | 15          | 24,30      | 32,89       | 35,51       | 37,38       |
| 4   | 20          | 23,58      | 31,92       | 34,46       | 36,28       |
From the graphic above (Figure 4) it can be seen that the results of the replacement of sand with stone ash for concrete compressive strength at 28 days are as follows:

- Replacement of 5% stone ash to the concrete compressive strength decreased by 39.37 MPa; this strength was reduced by 0.63% from the normal concrete compressive strength.
- Replacement of 10% of rock ash to the compressive strength of the concrete decreased by 38.32 MPa; this power was reduced by 1.68% from the normal concrete compressive strength.
- Replacement of 15% of rock ash against concrete compressive strength decreased by 37.38 MPa; this strength was reduced by 2.62% from normal concrete compressive strength.
- Replacement of 20% rock ash to the compressive strength of the concrete decreased by 36.28 MPa; this strength was reduced by 3.72% from the normal compressive strength of the concrete.

5. Conclusion
From the results of research conducted in the laboratory, the following conclusions can be drawn:

1. From the test results, the normal concrete compressive strength is 40.17 Mpa.
2. Replacement of 5% stone ash to concrete compressive strength decreased by 39.37 Mpa; this strength was reduced by 0.63% from the normal compressive strength of concrete. Replacement of 10% stone ash to concrete compressive strength decreased by 38.32 Mpa; this power was reduced by 1.68% from normal concrete compressive strength. Replacement of 15% stone ash to concrete compressive strength decreased by 37.38 Mpa; this strength was reduced by 2.62% from normal concrete compressive strength.
3. The replacement of 20% of rock ash against the compressive strength of the concrete decreased by 36.28 MPa; this strength was reduced by 3.72% from the normal compressive strength of the concrete.
4. Testing Results Slump Value On Normal Concrete Of 9.5 cm, On Replacement Of 5% stone ash of 8 cm, On Replacement Of 10% stone ash of 7 cm, On Replacement 15% stone ash of 6.5 cm, On Replacement 20% ash stone as big as 6 cm.

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