Using of rice husk ash as material addition in mixing concrete by mixing 1 Cement : 2 Sand : 3G to increase the compressive strength

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Abstract. Concrete is a construction material with increased supply annually. Increased supply of concrete caused cement demand also increased while the price of cement also increased every year. Based on this case, some research was done by mixing additives that can improve concrete strength and reduce the amount of cement. One of the additives used is rice husk ash (RHA). However, the addition of RHA was not implemented in concrete with mixing by 1pc: 2ps: 3kr; while concrete mixing by 1pc:2ps:3kr are mostly used by local communities to construct multistory buildings in Pamekasan. Therefore, this study is done by adding the RHA of 0%, 3%, 5%, 7% and 9% of the weight of cement is added. Concrete compressive strength testing was performed on all types of samples on the concrete curing periods 7, 14, 21 and 28 days. Concrete compressive strength test results showed that the addition of 5% RHA is able to provide increased compressive strength of concrete is the most optimal compared to the percentage of the RHA. At the curing periods of 28 days of concrete with 5% RHA.

1. Introduction
Concrete is a mixture of concrete-forming materials consisting of coarse aggregate (gravel), fine aggregate (sand) and cement and water as a catalyst to react to the mixture. The amount of concrete needs reaching 22.2 million cubic meters per year [1] proves that concrete construction has an important role in infrastructure development. The high demand for concrete in Indonesia also has an impact on the high demand for other concrete-forming materials, especially cement which is the most expensive material among other concrete-forming materials. PT. Semen Gresik [2] as the largest cement producer in Indonesia said that cement demand growth increased 6.5% annually so that it was predicted that in 2015 national cement demand would reach 56 million tons per year where more than 50% of national cement needs were met by the company.

Based on those cases, a lot of concrete material research was carried out with the aim of increasing the compressive strength of concrete and reducing the cement content of the concrete. One of the additives that are widely used in concrete mixes is Fly ash. It is of waste material from PLTU (Steam Power Plants) which are widely available in Indonesia. The addition of fly ash in concrete can increase the compressive strength until 37.5% than initial compressive strength [3] and is able to reduce water absorption which means more savings on water use; In addition, several studies said that adding 10% of fly ash is the most optimal addition to increase the compressive strength of concrete [4].

The increasing use of fly ash directly raises the economic value of fly ash so that other materials more economical are needed and must have chemical content that is same as that of fly ash. Yulianto
[5] stated that rice husk ash is a waste material that has same chemical content as fly ash and even the silica content in rice husk ash is higher than the silica content of fly ash. Silica from rice husk ash can reach 91.72% [6]. Based on this, Zayyad [7] uses rice husk ash as an additive in concrete with fc 20 Mpa. The percentage of concrete used in the study was 5%, 10% and 15%. The percentage of 5% rice husk ash gives an increase in the compressive strength about 10% of the initial strength. While the addition of rice husk ash for the percentage of 10% and 15% shows the compressive strength is lower than the initial conditions [7].

From the explanation above, it known that the more percentage of rice husk ash (RHA) that given causes the compressive strength of the concrete continuously decreases. However, it is still unknown whether the addition of 5% admixture is the most optimal percentage because the research was conducted using a large percentage range of every 5%. Based on this, it is important to conduct further research for the addition of percentage with a range of 2% so that the addition of the compressive strength of the concrete produced can increase more than 10% than initial strength. Addition of additives in the concrete mixture that will be carried out in this study are 3%, 7% and 9% to the weight of cement added with the ratio of the concrete material used is 1ps: 2ps: kr (1 cement: 2 sand: gravel). The selection of the comparison of the material is based on the habits of the people in Pamekasan and it ease of implementation during the research. So it is expected that concrete will be produced which has a better and more economical compressive strength compared to concrete added with other additives.

2. Research method

This research is a laboratory-scale research less than 1 year. The percentage of RHA added was 3%, 5%, 7% and 9% of the weight of cement added. Based on the results of previous studies conducted by Zayyad [7]. The concrete mixture used is 1 cement: 2 sand: 3 gravel, this mixture was chosen because almost all people in Pamekasan and its surroundings use this mixture in every construction. Concrete materials consist of pasirian sand, local gravel and type 1 cement as shown in Figure 1 and Figure 2. While RHA was obtained from brick industry in Pamekasan (Figure 3).

![Figure 1. Local gravel of Pamekasan.](image1.png)

To determine the quality of sand and gravel used for gradation, moisture content, sludge and abrasion testing was carried out based on SNI 2002. While the water used was water from PDAM (Drinking Water Company). Concrete samples mix 1pc: 2ps: 3kr based on weight comparison. The percentage of RHA added was 0%, 3%, 7% and 9% by weight of cement. Concrete samples made of 10 pieces as cylindrical, so that the total samples to be tested for compressive strength are 120 samples. Testing of concrete compressive strength will be carried out at 7, 14, 21 and 28 days.
3. Initial condition of concrete

Material tests carried out on sand and gravel showed that the sand and gravel used (Table 1) met the requirements for the manufacture of structural concrete based on SNI 03-2847-2002. The results of gradation tests (Figure 4 and Figure 5) on local sand and gravel are included in the range required by SNI 2002.

| No | Testing type | Pasirian Sand | Local Gravel |
|----|--------------|---------------|--------------|
| 1  | Sludge Level | 0.52%         | 0.46%        |
| 2  | Abrasion     | -             | 29.8%        |

The concrete compressive strength test results (Table 2) show that the mixture can produce good concrete quality when curing periods of concrete reaches 28 days (full strength). Concrete quality also increases with increasing curing periods and even possible the compressive strength of the concrete mix 1Pc: 2Ps: 3Kr will continue to increase according to the rules of increasing the value of concrete compressive strength [8].
Figure 4. Curve for Pasirian sand distribution.

Figure 5. Curve for local gravel distribution.

Table 2. Compressive strength of concrete with 0% of RHA.

| Cruing Periods (days) | Slump (cm) | Average compressive strength (kN) | Stress (kg/cm²) |
|-----------------------|------------|----------------------------------|-----------------|
| 7                     | 12         | 364.8                            | 162.13          |
| 14                    | 12         | 400.6                            | 178.04          |
| 21                    | 15         | 519.4                            | 230.84          |
| 28                    | 15         | 538.4                            | 239.29          |

4. Behavior of concrete with rice husk ash

To determine the effect of adding RHA on the concrete compressive strength, the percentage of RHA added is 3%, 7% and 9% while for concrete with 5% RHA the data will be taken from previous research conducted by Yulianto and Mukti [9]. The addition of RHA to concrete is expected to be able to fill the pores of the concrete so that the concrete pore space is smaller and its compressive strength increases compared to before. Figure 6 shows the behavior of concrete compressive strength with variations in RHA percentage mixture at 7 days. At the early curing periods, the addition of RHA still did not show a significant increase in the compressive strength of the concrete, even compared to the compressive strength of the concrete without the addition of RHA (0%); addition of RHA does not provide an increase in concrete compressive strength except for concrete with 5% RHA. This may be due to the RHA being mixed still not forming a gel that is able to fill the pores of the concrete well.
The increase in concrete compressive strength occurs when curing periods at 14 days (Figure 7). Concrete with the addition of 3% and 5% RHA has increased better than 7 days (especially 5%). While concrete with the addition of ASP 7% and 9% is still below the concrete with 0% RHA. This behavior is caused by a large percentage of RHA so that the mixed water (FAS) is insufficient to react between concrete materials because the RHA have high absorption capacity causes more pore in concrete [9].

The effect of RHA in concrete compressive strength is really increase when the curing periods reaches 21 days (Figure 8). When the compressive strength of concrete with RHA 0% - 5% when curing periods more long time; the value of concrete compressive strength with 7% and 9% RHA still below 175 kg/cm\(^2\). This behavior reinforces previous statements that the addition of more RHA will cause more pores in concrete and reduce the compressive strength.
Figure 9 shows concrete compressive strength at 28 days when the concrete has been having 100% strength (PBI'71, SNI'92 and SNI'2002). At curing periods of 28 days, all types of concrete compressive strength increase compared than before (21 days). However, the highest concrete compressive strength was obtained addition of 5% RHA which increased by 24% compared than RHA 0%. While in concrete with 3% RHA the increase in compressive strength is only about 17% because the percentage of RHA added is still not sufficient to cover the pores of the concrete very well.

The effect of curing periods and the addition of RHA on the overall compressive strength can be seen from Figure 10. Based on the explanation above and Figure 10 it is known that the percentage of maximum RHA that must be added to the concrete mix 1pc: 2ps: 3kr is 5%. Scanning Electron Microscope (SEM) test results also showed that the addition of RHA (especially 5% RHA) was able to cover the concrete pore very well (Figure 11) so that the compressive strength increased compared to conditions without RHA.

![Figure 9. Concrete compressive strength curve at 28 days.](image)

![Figure 10. Curve behavior of concrete compressive strength and percentage of RHA addition and concrete age.](image)
Figure 11. SEM 2000x magnification image; a) concrete with 0% RHA, b) concrete with 5% RHA.

5. Conclusion
Based on the results of laboratory tests carried out, it can be concluded, there are:

- The Parisian sand and local gravel used in this study have fulfilled requirements specified in SNI 1991 and 2002 for testing the sludge level and gradation.
- Concrete compressive strength without RHA has 162 kg/cm² at 7 days and the compressive strength increases to 239 kg/cm² when curing periods 28 days.
- Increased compressive strength of concrete due to the addition of RHA has start when 14 days for concrete with 3% and 5% ASP while the concrete with 7% and 9% RHA, the compressive strength was still below concrete without RHA (0% RHA).
- The results of laboratory testing revealed that the addition of 5% ASP gave the highest concrete compressive strength, that is 295 kg/cm² at 28 days or increase 24% compared than 0% RHA.

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