Effect of fire extinguish methods on RHA-concrete strength

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Abstract. During the few past years reuse these materials to enhancement the mechanical properties of concrete are one of the aims of concrete technology. The previous researches turn the rice hulls into rice husk ash by different methods. In this research, RHA were prepared by two methods which are oven burning at 200ºC and exposure to direct flame. Concrete cubes with 4%, 8%, 12%, and 16% by weight of cement were prepared and tested under compression test to achieve the optimum percentage of replacement and RHA preparation method. Then, three groups of RHA concrete cubes were casted and exposed to direct fire for one hour. One group of them tested directly to study the enhancement of fire resistance of RHA concrete and act of RHA in concrete fire resistance while, the other groups extinguished by two different methods (Water, and Powder) to study the effect of fire extinguish method on concrete strength. The results found that oven burning rice husk produce RHA better than direct flam. Effect of fire extinguish method has nearly the same effect on the reduction in concrete compressive strength and flexural strength. Concrete fire resistance for RHA concrete is higher than the conventional concrete.

Keywords: Oven Burning; Direct Flame; Concrete Strength, Fire Extinguish

1. Introduction

The Rice Husk is the outer shell of the rice grain. Rice milling machines separate the rice far from its husk. Rice milling machines produce more than 100 million tons per year around all the world. So, the rice husk ash is agricultural waste wealth [1].

The rice husk is the finally product of combustion of rice hulls. It is a pozzolanic material which makes it suitable to replace the cement in concrete. RHA has a high amount of silicon dioxide, and its reactivity to lime depends on a combination of two factors, namely the non-crystalline silica content and its specific gravity [2].

Many researchers studied the effect of different RHA percentages of the weight of cement in concrete as a partial replacement of cement ranged from (0% to 30%) on the concrete compressive strength, tensile strength, and flexural strength. Although, most of the researchers found agree with the enhancement in the mechanical properties of the modified concrete and they also agree that the enhancement in compressive strength is higher than the enhancement in tensile strength, but the researches did not agree with optimum RHA percentage or the percentage of increase in the compressive strength [3-7]. On the other hand, some researchers found that the RHA has a negative
effect on the compressive strength and flexural strength [8,9]. The increase in RHA percentages in modified concrete decrease the workability, the drying shrinkage, consistency, cohesiveness and plasticity of concrete [10-12].

RHA produced by burning rice husk in open field or by any method of combustion. Burning rice husk in open field produce RHA with high carbon content which caused highly crystalline form in concrete structures [13]. Different methods for combustion of rice husk were discussed in previous researches [14-17]. Quality of RHA depends on combustion process amorphous which is essential for concrete structure [18]. Burning rice husk at temperature ranges of 500–700 °C and specific gives the highest amorphous silica and surface area up to 150 m²/g will be maximum at that temperature [18-23].

However, compressive strength, elasticity, density of concrete is decreased with high temperature, but using pozzolanic materials as a replacement of cement or as mineral additives such as RHA, limestone powder, slag, and fly ash can improve the concrete fire resistance.

According to previous overview, RHA has no the same effect on mortar or concrete. Some researchers found RHA has a positive effect on the concrete strength, while the other researchers found the reverse. The reason to that may be the source and the type of rice hulls or may be the mechanism of combustion rice husk to produce rice husk ash. Therefore, this research studies two preparation methods of rice husk ash.

2. Experimental Work

2.1. Preparation of RHA

Two types of RHA were used to study the effect of burning method on the RHA characteristics. One of them was oven burning (O.B) at 200º C and the other was exposure to direct flame (D.F). Chemical analysis tests were carried out for the two types of RHA to determine their chemical composition. Table (1) represents the chemical analysis of RHA while. The two types of RHA were blinded to achieve a degree of fineness near that of cement fineness and the fineness test of sieve No. 170 was carried out to ensure that.

| Chemical Composition | Oxide Content (%) | Chemical Composition | Oxide Content (%) |
|----------------------|-------------------|----------------------|-------------------|
|                      | RHA Burnt in Standard Oven | RHA exposed to direct flame | RHA Burnt in Standard Oven | RHA exposed to direct flame |
| SiO₂                 | 80.78             | 43.80                | TiO₂               | 0                  |
| Al₂O₃                | 0.23              | 0.24                 | MnO                | 0.07               |
| Fe₂O₃                | 0.29              | 0.19                 | SrO                | 0                  |
| CaO                  | 1.08              | 0.63                 | Cr₂O₃              | 0                  |
| MgO                  | 1.76              | 1.04                 | ZnO                | 0.01               |
| SO₃                  | 0.86              | 0.36                 | Cl⁻                 | 0.76               |
| Na₂O                 | 0.39              | 0.30                 | LOI                | 5.46               |
| K₂O                  | 4.37              | 2.46                 | TOTAL              | 99.99              |
| P₂O₅                 | 3.93              | 2.18                 |                    | 99.97              |
2.2. Effect of RHA percentage on concrete compressive strength
For both RHA preparation methods, five concrete mixes with four different RHA percentages (4, 8, 12, and 16%) in addition to the normal concrete were prepared. For each mix six standard concrete cubes (15x15x15 cm) were casting and slump was measured to study the consistency behavior of modified fresh concrete. In addition to compression test and flexural test which carried out to evaluate the effect of RHA percentage and type on the compressive and flexural strength of hardened concrete.

2.3. Effect of RHA on concrete fire resistance
After achieving the optimum RHA percentage from the previous stage, it is used to casting 18-standard concrete cubes and 18-concrete prisms to study the enhancement in fire resistance of modified concrete in addition to the effect of fire extinguish method. The cubes divided into 3-groups and all groups exposed to direct fire from all sides to one hour. The first group tested directly after burning, the second group extinguish by water then it is tested, and the last group extinguish by chemical dioxide powder then it is tested.

3. Results and discussion
Five modified concrete mixes with RHA percentages 0, 4, 8, 12, and 16% for both oven burning of RHA and RHA exposed to direct flame were prepared. The slump of these mixes was measured and illustrated in figure (1). Also, compression test was carried out on the same mixes to study the effect of RHA on the compressive strength of modified concrete as shown in figure (2).

From figure 1, increase in RHA percentage decreases the slump in both RHA preparation method. The reason being that the gluttonous RHA particles absorb the mixing water more rapidly than the cement particles. Effect of Burning RHA preparation method is nearly as the same as exposing RH to the direct flam to prepare it.

Figure 2 show that the optimum percentage of RHA is 8% which increase the compressive strength by 16% and 5% for O.B. RHA and D.F. RHA respectively at 28 days. The effect of O.B. RHA is 3-times the effect of D.F. RH because of the content of silicone dioxide and calcium dioxide which are much more in case of O.B. RHA.
Based on the results obtained from figure 2, different modified concrete mixes with 8% RHA were prepared to study the effect of RHA on fire resistance of concrete and the rule of different methods of fire extinguish as shown in figure 3.

![Figure 2. Effect of RHA on Compressive Strength.](image)

![Figure 3. Effect of RHA on the fire concrete compressive strength.](image)

According to figure 3, RHA modified concrete has high fire resistance more than conventional concrete. Using 8% RHA as a replacement of cement increase the compressive strength by 16% at the normal weather condition. Exposing conventional concrete to fire up to one hour decreases the compressive strength by 32%, while the decrease is 15% in case of RHA modified concrete which reach approximately the strength of the conventional concrete before burning.
Figure 4 show that for all fire extinguish method, compressive strength of RHA modified concrete is higher than the compressive strength for conventional concrete after burning. Best fire extinguish method is chemical powder which decrease the compressive strength by 24% in case of conventional concrete while the reduction in compressive strength is 12% in case of modified concrete. In conventional concrete, fire extinguish by water and testing directly after burning has nearly the same reduction in compressive strength which is about 30%. In case of modified concrete, the worst fire extinguish method is water which decrease the compressive strength by 25% and that because the gluttonous RHA particles absorb the extinguish water which leads to high volumetric change.

As shown in figure 5, RHA modified concrete with 8% RHA increase the flexural strength increase by 35%. For all fire extinguish methods, flexural strength of RHA modified concrete is higher than the flexural strength of conventional concrete. Fire extinguish methods have nearly the same effect on the flexural strength for the same concrete mix. Fire decrease the flexural strength by 24% and 35% for conventional concrete and RHA modified concrete.

Figure 4. Effect fire extinguish method on concrete compressive strength.

Figure 5. Effect fire extinguish method on concrete flexural strength.
4. Conclusions
According to the results obtained from this research, the following conclusions can be drawn:

• Method of Burning rice husk has significant effect on the RHA composition.
• Burning rice husk in oven produces higher silica percentages in RHA.
• RHA modified concrete with 8% RHA increase the compressive strength and the flexural strength by 16% and 35% respectively.
• Effect of fire on conventional concrete compressive strength is higher than its effect on RHA modified concrete.
• Effect of fire on RHA modified concrete flexural strength is higher than its effect on conventional concrete.
• Fire extinguish methods have no significant effect on concrete flexural strength.
• Fire extinguish by water has is undesirable for RHA modified concrete

5. References
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