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Laboratory Study of Reinforced Concrete with Rice Husk Ash and Microsilica in Terms of Compressive and Tensile Strength

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Abstract

Today, concrete is widely used due to the use of materials with a lower price and good durability, and based on the development of common concrete technology, the construction of high-strength concrete has become popular in the design of executive structures in advanced countries of the world. According to some regulations, the minimum resistance for high-strength concrete is considered to be 55 MPa, and a resistance of this level is more attainable in laboratory conditions. Among its advantages, we can mention the increase in strength and hardness, which can reduce horizontal displacements, as well as the length of restraint and patch of rebars. Also, in order to reduce environmental pollution and increase the durability and reliability of the structure, the use of Micro Silica (MS) and Rice Husk Ash (RHA) instead of a part of all cement consumption is considered. This thesis deals with the properties of concrete containing MS and RHA. In total, two mixing plans were made with two water-to-cement ratios of 0.37 and ratios at the age of 7 and 28 days. The durability performance of high-strength concrete containing RHA and MS was measured using compressive strength, tensile strength, and elastic modulus tests. The results of the tests show that the compressive strength of concrete containing MS is higher than that of concrete containing RHA, and the tensile strength of concrete containing RHA is higher than the compressive strength of concrete containing microsilica.

Keywords: Strong concrete, Rice husk ash, Micro silica, Compressive strength, Tensile strength.

1 | Introduction

Recently, the use of high-strength concrete in all kinds of structures, such as bridges, sea piers, tall buildings, etc., has attracted the attention of researchers in the construction industry. One of the most important constituents of high-strength concrete is aggregates, whose characteristics can have a direct effect on the mechanical properties of concrete, but considering that aggregates are extracted from natural sources such as rivers. Since their preparation can have harmful environmental effects, in recent years, different research has

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been conducted to use alternative materials instead of natural aggregates. Among these materials, they are substitutes for recycled aggregates, which can be mentioned as MS and Rice Husk Ash (RHA) [1].

Zarei et al. [2], conducted research. In this article, the primary and inevitable interest in using partial substitutes or byproducts as complementary materials was mainly led by the implementation of air pollution control from the cement production industry. Increasing the husk byproduct from the rice milling process, with a ratio of about 200 kg per ton of rice, reduces it to 40 kg even at high temperatures.

This article examines the advantages of different ratios of RHA on concrete indices through 5 mixing designs with the ratio of 5, 10, 15, 20, and 25% RHA to the weight of cement in addition to 10% Micro Silica (MS) with the mixture The reference should be compared with 100% Portland cement. The test results showed that the positive relationship between 15% replacement of RHA with an increase in compressive strength of about 20%, the desired level of abilities and durability properties generally increases with the addition of 20%, beyond that with a slight decrease in strength parameters of about 5, 4% is included. Similar results for the water absorption ratio are likely to be unfavorable. Chloride ion penetration increases by increasing the amount of cement replacement by about 25% compared to the initial values (about less than one-fifth).

Anwar et al. [3], nanotechnology is progressing rapidly. Due to the serious applications of nanoparticles, interest, and attention have been drawn to research related to the effect of nanoparticles, especially on concrete and cement mortar. Most of the existing studies have focused on the effects of Nano-Sio2 on the properties of hardened cement paste, meth-cement, or concrete. Kouing and his colleagues experimentally investigated the effects of Nano-Sio2 on the properties of hardened cement paste.

Joe et al. [4] also studied the effect of Nano-Sio2 on the characteristics of cement mortars. Lee and his colleagues researched the effects of Nano-Sio2 and Nano-Fe203 on the mechanical properties of cement mortars. Lee investigated the impacts of Nano-Sio2 on the mechanical properties of high-volume fly ash concretes. Changes over time have accompanied the production methods of high-strength concrete. In the 1950s in China, high-strength concrete was produced using high-quality cement. However, due to the limited production of these types of cement, this method did not meet the relevant needs, and high-strength concrete was produced with ordinary cement. It was replaced very quickly.

The most important factor that determines the strength of high-strength concrete is porosity in the three phases of concrete (aggregate, cement paste, and transition zone). The ratio of water to cement determines the porosity of the hydrated cement paste and the transition zone (the area between the cement paste and coarse aggregates). In low water-cement ratios, it has been observed that by slightly reducing the water-cement ratio, great resistance can be obtained. Research shows that with water-cement ratios of 0.38, 0.36, and 0.34, compressive strengths of 40, 52, and 60 MPa can be achieved [5].

In the distant past, rice paddy husk was considered a waste material that had no special use and had many harmful environmental effects. Due to its energization and suitable flammability, it was used as a fuel in activities such as rice drying process, brick-making factories, and home heating, and these applications have remained strong until today [6]. This type of rice paddy husk burning causes the production of silica ash, the color of which changes from gray to black depending on the inorganic impurities and the amount of carbon remaining in it. With the passage of time and increasing environmental challenges, various researchers and related parties have been thinking of finding a way to prevent environmental pollution from this substance.

2 | Research methods

2.1 | Library method

The library method is used in all scientific research, and in some of them, the research topic relies on the findings of the library research from the beginning to the end. In research that is not of a library nature, researchers are also forced to use the library method. In this research group, the researcher must study the literature and records of the problem and research topic. As a result, he should use the library method and store and maintain the results of his studies with appropriate tools, including slips, tables, and forms, and finally classify and exploit them.

The researcher's information collection tool in the library method, all printed documents such as books, encyclopedias, dictionaries, magazines, newspapers, weekly magazines, monthly magazines, dictionaries, yearbooks, printed interviews, research papers, scientific conference books, printed texts indexed in databases and Internet and any source that can be identified in print.

2.2 | Laboratory methods

In order to achieve appropriate and reliable results, the possibility of repeating the tests, and also increasing the validity of the tests, it is necessary to fully explain the exact characteristics of the materials, the way of making the tested samples, and the steps of preparing the tests. In this chapter, the characteristics of the materials used for the construction of samples, including sand, cement, microsilica, and RHA, are introduced, and the tests performed on each of them are described separately.

In the rest of the chapter, the stages of preparing the tests, including naming the samples, water-cement ratio, how to process the samples, calibrating the devices, and also the preliminary mixing plan (in order to choose the best mixing plan before starting the tests) are briefly explained. The things discussed in this chapter help to give a better understanding of the future chapters and make the main experiments more valid.

2.3 | Specifications of the materials and materials used in the experiment

The materials used for the experiments are as follows:

2.3.1 | Mechanical properties of cement

The cement used in all the tests is medium anti-sulfate Portland cement (type two) from the products of the Bojnoord factory. According to the tests, all the specifications of the cement used are completely in accordance with the required standards. The preliminary tests of cement, which can be performed in the concrete technology laboratory, have also been performed on cement.

Table 1. Consumable mechanical properties.

Test number in the relevant standard	The result	Type of test
ASTM-C188-89	15/3gr/cm^3	Specific weight of cement
ASTM-C191-82	After 3 hours	Initial setting time of cement
ASTM-C187-86	0.26	Normal cement concentration

2.3.2 | Microsilica

Microsilica is a byproduct of immersion-type electric furnaces during the production of silicon or silicon alloys, especially ferrosilicon alloys. Microsilica particles are usually spherical and with an average diameter of about 0.1 to 0.2 microns in a non-crystalline state. Its silica content is 85% to 95%, which depends on the type of product and the silica factory. The main purpose of using MS, in the beginning, was to replace a part of cement with these waste materials to reduce the cost of cement, but today, with the increase in the price of MS in most countries of the world, the above application is no longer affordable. Therefore, MS is a material that replaces it. It becomes a part of cement, and it is added to the concrete mixture to obtain the required properties [7].

The MS used in this research was produced by Jat Ferrosilis Factory of Iran, which has a specific mass of 2.2gr/cm3 and a volume of 20.2m2/gr, and its chemical test is presented in *Table 1*, as well as the characteristics of MS in *Table 2*.

Fig. 1. Shape and size of microsilica in the experiment.

Table 2. Chemical characteristics of micro silica used in this research.

Chemical compounds	Microsilica
SiO_2	94.77
Fe_2O_3	0.87
Al_2O_3	1.32
CaO	0.49
MgO	0.97
Na_2O	0.31
K_2O	1.01
P_2O	0.16
SO_3	0.1

Table 3. Specifications of consumable micro silica.

Spherical and non-crystalline	Structure
Grayish white	color
2/12gr/cm^3	density
7	PH
12 percent of cement weight	Amount of consumption
0.05 to 0.15 microns	Granulation
11 percent of cement weight	Optimal percentage

2.3.3 | Rice husk ash

The characteristics of rice paddy husk ash used are shown in *Table 4*. There is also a picture of rice paddy husk ash in *Fig. 2*.

Table 4. Characteristics of rice paddy husk ash.

Powder	Structure
Brown cream	Color
2/23gr/cm3	Density
10 of cement used % of the weight	Optimal consumption

Fig. 2. A picture of RHA used in this study.

2.3.4 | Water

The water used in making concrete comes from the drinking water of Tankabon City, which is not a problem considering its potable use for making concrete .In addition, the optimal amount of water consumption in this concrete is 3.3 kg/m3.

2.3.5 | Sand

The Sand used in this thesis is a type of factory-crushed stone. A maximum of 19 mm has a water absorption of 1.01% and a specific weight of 2650 kg/m3.

Table 5. Sand grading table.

Sieve number	Full	Vacant	Pure
$1\frac{1}{2}$	384.52	384.52	0
1	471.47	471.47	0
$\frac{3}{4}$	614.40	445	169.4
$\frac{1}{2}$	992.19	462.02	530.17
$\frac{3}{8}$	655.15	408.85	264.3
4	547.11	445.13	101.98
The last dish	232.10	208.85	23.25

2.3.6 | Sand

The Sand used is also prepared from the riverbed, and its maximum grain size is 75.4mm. It has a water absorption of 5.28% and a specific weight of 2600 kg/m3.

Table 6. Sand grading table.

Sieve number	Full	Vacant	Pure
8	1/02Kg	451/45gr	586/55gr
16	512/19gr	316/16gr	196/03gr
30	363/62gr	292/38gr	91/24gr
50	334/85gr	288gr	46/85gr
100	311gr	254/82gr	56/18gr
200	285/75gr	255/93gr	29/64gr
The last dish	213/08gr	208/91gr	4/87gr

Softness modulus is a single number that is obtained from the results of the sand granulation test and is equal to the sum of the cumulative percentages remaining on sieve number 100 and the sieves above it, divided by hundred and representing the average size of sand grains. A low modulus of elasticity indicates that the Sand is fine-grained, and a high modulus of elasticity indicates that it is coarse-grained [7]. The ASTM C33 standard specifies that the modulus of elasticity of sand used to make concrete should be between 1.3 and 2.3

2.3.7 | Mixing plan

Table 7. Concrete mixing plant.

Grade of concrete	Microsilica	Rice paddy husk ash	Water	Cement	Sand	Sand
350	1/05kg/m^3	-	3/3kg/m^3	8/75kg/m^3	16/75kg/m^3	28/25kg/m^3
350	-	0/875kg/m^3	3/3kg/m^3	8/75kg/m^3	16/75kg/m^3	28/25kg/m^3

3 | Concloutions

In this research, the following results are obtained

I. The 7-day compressive strength of concrete containing microsilica and RHA is higher than its 28-day strength.

II. The 28-day compressive strength of concrete containing RHA is lower than the 28-day compressive strength of concrete containing MS.

III. The 7-day compressive strength of concrete containing RHA is higher than the 28-day compressive strength of concrete containing MS.

IV. The tensile strength of concrete containing RHA is higher than the compressive strength of concrete containing MS.

V. The elastic modulus of concrete containing twelve microsilica has a higher modulus of elasticity than concrete containing RHA.

VI. The comparison of compressive strength results with previous research on other types of concrete shows that in high-strength concrete, the loss of strength with age and the corresponding percentage of replacement is less than in other types of concrete.

References

[1] Hamad, A. J. (2017). Size and shape effect of specimen on the compressive strength of HPLWFC reinforced with glass fibres. *Journal of king saud university-engineering sciences*, *29*(4), 373–380. DOI: 10.1016/j.jksues.2015.09.003

[2] Ehsani, A., Nili, M., & Shaabani, K. (2017). Effect of nanosilica on the compressive strength development and water absorption properties of cement paste and concrete containing Fly Ash. *KSCE journal of civil engineering*, *21*(5), 1854–1865. DOI: 10.1007/s12205-016-0853-2

[3] Mohamed, A. M. (2016). Influence of nano materials on flexural behavior and compressive strength of concrete. *HBRC journal*, *12*(2), 212–225. DOI: 10.1016/j.hbrcj.2014.11.006

[4] Zareei, S. A., Ameri, F., Dorostkar, F., & Ahmadi, M. (2017). Rice husk ash as a partial replacement of cement in high strength concrete containing micro silica: Evaluating durability and mechanical properties. *Case studies in construction materials*, *7*, 73–81. DOI: 10.1016/j.cscm.2017.05.001

[5] ACI Committee 234. (1995). *Guide for the Use of Silica Fume in concrete*. ACI material journal. http://dl.mycivil.ir/dozanani/ACI/ACI 234R-06 Guide for the Use of Silica Fume in Concrete_MyCivil.ir.pdf

[6] Prashant, Y. P., Nagarnaik, P. B., & Pande, A. M. (2011). Influence of Silica fume in enhancement of compressive strength, flexural strength of steel fibers concrete and their relationship. *International journal of civil & structural engineering*, *2*(1), 43–55. DOI: 10.14359/4009

[7] Hooton, R. D. (1993). Influence of silica fume replacement of cement on physical properties and resistance to sulfate attack, freezing and thawing, and alkali-silica reactivity. *Materials journal*, *90*(2), 143–151. https://trid.trb.org/View/372885