Evaluation of the effectiveness of straw fibers on the mechanical properties of concrete containing zeolite and bentonite

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ABSTRACT

Cement is one of the most widely used materials in the construction industry, which emits large amounts of carbon dioxide into the environment during production. Environmental challenges and the reduction of energy consumption and the use of natural raw materials have led to increased study and research to find a suitable alternative to cement. Zeolite and bentonite have cement properties. These materials are environmentally friendly and can be easily extracted and also have lower production costs than cement. Natural straw fibers are used as the concrete has low tensile strength. In this research, 9 different mixing ratios with the amount of 250 kg / m^3 cement were made in which different percentages of bentonite and zeolite replaced part of the original cement and the percentage of fibers varied by 1% and 3%. After fabrication, the compressive strength and tensile strength of the samples compared to the reference sample at 7 and 28 days were compared. Then, two concrete mixtures with 6% zeolite, 1% straw fiber and 6% and 16% bentonites were selected and three-point bending strength test was performed on beams with dimensions of 10 * 10 * 50 cm. The flexural strength of the reference sample containing 350 kg / m^3 of cement, was 5.37 MPa in this section. It was finally figured out that optimum composition contains 6% zeolite, 6% bentonite and 1% straw fiber and is able to achieve 98% flexural strength compared to the reference sample.

KEYWORDS

zeolite, Bentonite, straw fiber, Bending strength, Global warming potential.

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1. Introduction

One of the most important issues that has attracted the attention of researchers today is the phenomenon of climate change and global warming due to greenhouse gas emissions. According to research conducted in the cement production process, about 7% of the world's carbon dioxide gas accounts for global warming and intensifies the destructive effects of greenhouse phenomena[1]. Natural pozzolans can replace all or part of the cement. If these particles are well separated, they have the ability to react chemically with calcium hydroxide resulting from the hydration of cement in the presence of moisture and form compounds with the properties of cement products [2]. These materials are environmentally friendly and have a good performance and durability over time. Zeolites and Bentonites are of the natural pozzolans. The effect of bentonite on the compressive strength of concrete is one of the under-research topics. According to the results, in the early ages (3 and 7 days) of the reaction, bentonite has a compressive strength of about 10-12 MPa, but in older ages (90 days), it has a suitable compressive strength of 25-30 MPa [3]. In this study of the effect of zeolite on the compressive strength of concrete, it was observed that the compressive strength of concrete containing zeolite is lower than of the reference sample that does not contain zeolite at the ages of 7 and 28 days. However, the percentage of reduction in older concrete ages of 90 and 180 days is less or even zero[4]. The reference sample and the samples containing 1% of straw fibers achieved about 50% of the compressive strength of the reference sample [5]. The aim of this study was to investigate the mechanical properties of low-cement concretes by simultaneously replacing zeolite with different percentages of bentonite instead of part of cement and natural straw fibers. Each of these materials is environmentally friendly and does not require a lot of energy to produce.

2. Experimental program

First, 9 mixing ratios with 250 kg / m^3 cement having different replacement ratios of pozzolanic materials and straw fibers are considered. The replacement rate for zeolite is a fixed value of 6% while ,for bentonite, it is 3% different (6, 10 and 16) and also for straw fibers is 2% different (1 and 3). After fabrication, the specimens were examined under compressive and tensile loading according to ASTM c39 and ASTM C496 standards at 7 and 28 days. Selected specimens are subjected to three-point bending test according to ASTM C293 standard on beams with dimensions of 10 * 10 * 50 cm. Figure 1 shows how the samples are placed during the test.

Washed sand that passes through sieve No. 4 and prepared sand is broken with a maximum nominal size of 9 mm. Zeolite and bentonite are prepared from Semnan mines and used as a powder. The cement used is type two of Shahroud and the dry straw used has a maximum length of 4 mm. To explain the fabrication method, the sand is firstly poured into the mixer and mixed dry for 1 minute, then a quarter of the mixing water is poured into the mixer to mix the sand suitably, then the cement and pozzolanic materials that are already mixed together, are added dry to the mixer, and combined for another 1 minute. Water and dry straw are then slowly added to the mixture. The slump test is performed according to ASTM C143 and the average low surface area of concrete is between 60 mm and 80 mm.

b.tensile test **a. Compression test**

C- Three-point bending test

Figure1. Placement of samples during the test

The prepared mixture is poured into cylindrical molds with a diameter of 100 mm and a height of 200 mm and the compaction of concrete in the molds is done using a vibrating table in the laboratory according to the standard. Samples are removed from the molds after 24 hours and submerged in a pond to be processed for 7 and 28 days. The ratio of water to cement is 0.75. The mixing scheme of the samples is given in Table 1.

Table 1. Mixing design of studied samples

name	Cement (kg)	Zeolite (%)	Bentonite (%)	Straw fiber (%)
6b6z-1st	250	6	6	1
10b6z-1st	250	6	10	1
16b6z-1st	250	6	16	1
6b6z-3st	250	6	6	3
10b6z-3st	250	6	10	3
16b6z-3st	250	6	16	3
C250-1st	250	0	0	1
C250-3st	250	0	0	3
C250	250	0	0	0
C350	350	0	0	0

3. results

The compressive strength results of samples at the ages of 7 and 28 days are shown in Figure 2.

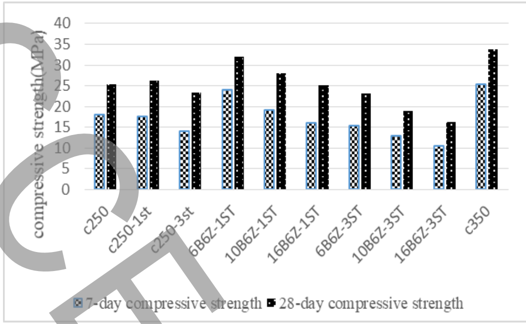

Figure 2. Results of compressive strength of samples at 7 and 28 days

By adding fibers up to one percent, the result was almost the same as the reference sample. At 7 and 28 days, with a constant amount of zeolite and percentage of fibers, by adding bentonite up to 10%, it increased the resistance at 7 and 28 days of age compared to the reference sample. With the addition of pozzolanic materials along with 3% of fibers, the amount of compressive strength at the ages of 7 and 28 days decreased compared to the reference sample. The addition of fibers to this extent affects the bonding of the cement matrix and reduces the bonding of cement gels and aggregates. The tensile strength results of samples at 7 and 28 days of age are shown in Figure 3.

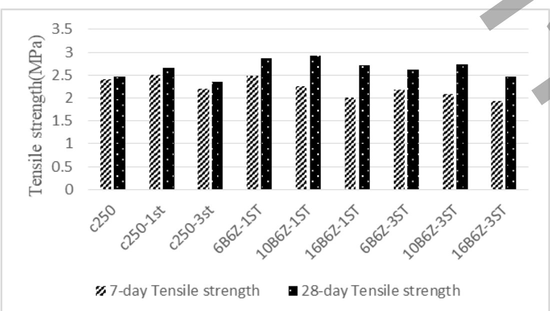

Figure 3. Results of tensile strength of samples at 7 and 28 days

Addition of fibers up to one percent improved the tensile strength at the ages of 7 and 28 days. . 7 and 28 days. The tensile strength of samples containing 1% straw is higher than that of samples with 3% straw. Comparing the results, it can be seen that 10b6z-1st and 10b6z-3st samples have higher tensile strength than other samples. It can be observed that the addition of fibers could enhance the increment of compressive strength in comparison with the increasing rate for tensile strength and it can be due to the proper functioning of the straw and bentonite and the size of the fibers used. The results of flexural strength of the specimens are shown in Figure 4 .By comparing the two designs 6b6z-1st and 16b6z-1st, it can be mentioned that by replacing 16% bentonite, the sample showed more brittle behavior and failed sooner.

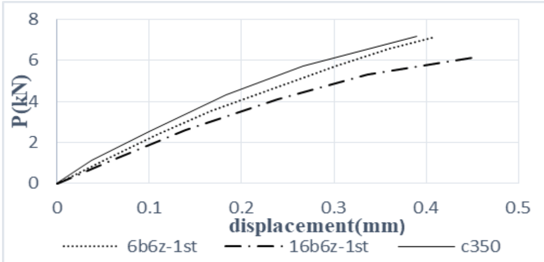

Figure 4. Three-point flexural strength diagram of the specimens

4. Conclusion

According to our experiments' results, the following results have been obtained:

The optimum percentage of fiber addition to increase the compressive strength is one percent. If zeolite is stable by adding bentonite up to 10% and using one percent of fibers at the ages of 7 and 28 days, an increase in compressive strength can be observed compared to the reference sample. Addition of 16% bentonite to the reference sample provides almost the same result at 28 days.

With constant zeolite content and 1% of straw fibers, addition of bentonite up to 10% increases 28-day tensile strength and addition of 16% bentonite reduces 28-day strength compared to the samples containing 6% and 10% bentonite.

If the percentage of zeolite changes, the optimum percentage of bentonite in bending is still 10%.

5. Refrences

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