Investigation of the behavior of recycled concrete and self-compacting concrete in road pavement construction using ultrasonic test and compare it with other methods

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ABSTRACT

Nowadays, recycled concrete is used for the construction of many construction projects due to its low cost and environmental protection. In addition, self-compacting concrete is very important and useful due to the lack of vibration and the least possibility of creating large holes and voids. In this article, by combining these two types of concrete, its properties have been investigated. To obtain the compressive strength of concrete, non-destructive methods can be used, which can be much simpler, faster and without damage, however, there must be agreement between the destructive and non-destructive test results to be acceptable. In this article, the behavior of recycled and self-compacting concrete used in road concrete pavements has been investigated. For this purpose, the method of grinding and ultrasonic testing has been used and a comparison has been made between the results. The average compressive strength of 7 days in cement grade of 250 kg/m3 is equal to 20.1 MPa and in cement grade of 400 kg/m3 is equal to 30.8 MPa, which has a growth of 52%. Also, in all the tests, the compressive strength obtained in the core sampling test was higher than the other results. On average, the value of compressive strength obtained in the core sampling method is 8% and 14% higher than the in-situ test method and ultrasonic test, respectively. The average compressive strength of 28 days in cement grade of 250 kg/m3 is equal to 25.2 MPa and in cement grade of 400 kg/m^3 it is equal to 38.9 MPa, which has increased by 54%. Finally, it has been concluded that the results of sanding and ultrasonic testing in determining the compressive strength of concrete can have a difference between 7 and 17%, and usually the results of ultrasonic testing show lower values.

KEYWORDS

Concrete, compressive strength, in situ test, ultrasonic test, corrugation test

Introduction

Today, the consumption of concrete is increasing day by day in various construction works, and the need to know more about the materials that make up concrete along with construction technology has been accepted in all engineering societies. Concrete consists of three phases: cement paste as a matrix, transition zone, and aggregate. The results obtained in many researches show that the size of aggregates has a great effect on the strength of concrete[1]. In projects whose structures are made of concrete, the most important characteristic is the concrete's compressive strength[2].

In addition, estimating the compressive strength of concrete without damaging the concrete sample has

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always been one of the main concerns of researchers[1]. Therefore, the method of ultrasonic waves can help in this goal. Measuring the speed of ultrasonic waves and estimating its relationship on the compressive strength of different mixes can help to measure the strength of the concrete sample without placing the concrete sample under the compressive strength measuring device and breaking it, just by measuring the speed of the ultrasonic waves of the concrete sample[3]. Its pressure was achieved, without the concrete sample being damaged[4]. The compressive strength measuring device is used to determine the 28-day compressive strength of the samples, and the ultrasonic speed measuring device is used to measure the speed of the ultrasonic waves of the samples, but usually their values are slightly different[5].

Nowadays, various researches have been conducted in the field of using neural networks in the design of concrete mixtures, mechanical properties of cement and concrete strength[6]. Usually, concrete strength is considered based on cubic or cylindrical samples[7]. But it is important to pay attention to this very important point that the samples tested in standard conditions may not be representative of the concrete used to make the real members[8].

Preparation of samples:

How to make mixtures:

All concretes are made by a mixer, and it should be mentioned that the method provided in Section 9 of Iran's National Regulations was used to mix the various constituents of concrete.

efficiency of mixtures:

The effectiveness of all mixtures was measured according to BS 1881: Part 102: 1983 standard using slump test.

Preparing the samples:

The recommendations of BS 1881: Part: 125: 1986 have been taken into account in making all the samples. For each mixture, three cubic samples with sides of 100 mm were made to measure the compressive strength at each age.

Implementation:

After concreting, the upper surface of all samples was quickly covered with nylon to prevent their water from evaporating in the first 24 hours. After the above time, the samples were removed from the mold and placed in Tehran water with a temperature of 20 degrees Celsius. It should be mentioned that the cubic samples related to the compressive strength and the rectangular cubic samples related to the tensile strength were kept in water until the test was performed.

compressive strength:

The compressive strength test was performed on 100 mm cubic samples according to BS 1881: Part 116: 1983.

Table1: Mixing plan of concrete samples

140kg/m^3	Water
350kg/m^3	Cement
0.4	W/C
1050kg/m^3	Gravel
860kg/m^3	Sand

The results of various tests and their comparison:

On-site laboratory results:

The results obtained in this section include samples made with changes in the grade of cement. Based on the changes in specific gravity in in-situ tests, it has been observed that by increasing the grade of cement up to 400 kg/m3, the value of specific weight has increased from 2360 MPa to 2418 kg/m3, which is an increase of 2.4%. Based on the 7-day compressive strength changes for in-situ tests in samples with different amounts of cement grade in the mixing plan, it has been observed that with the cement grade up to 400 kg/m3, the compressive strength value has increased from 19.7 MPa to 30.5 MPa, which is an equal to 54% increased. Based on the 28-day compressive strength changes for in-situ tests in samples with different amounts of cement grade in the mixing plan, it has been observed that with the cement grade up to 400 kg/m3, the compressive strength value has increased from 24.6 MPa to 38.1 MPa.

Ultrasonic test results:

The results obtained in this section include samples made with changes in the grade of cement. Based on the changes of specific gravity in ultrasonic tests, it has been observed that with the increase of cement grade up to 400 kg/m3, the value of specific weight has increased from 2360 MPa to 2418 kg/m3, which is an increase of 2.4%. Based on the 7-day compressive strength changes for ultrasonic tests in samples with different amounts of cement grade in the mixing plan, it has been observed that with cement grade up to 400 kg/m3, the compressive strength value has increased from 18.8 MPa to 29.3 MPa, which is an equal growth with 56%. Based on the changes in compressive strength of 28 days for ultrasonic tests in samples with different amounts of cement grade in the mixing plan, it has been observed that with cement grade up to 400 kg/m3, the compressive strength value has

increased from 25.1 MPa to 39.2 MPa, which is an equal growth with 56%.

Core drilling test results:

Based on the changes in specific weight in core drilling tests, it has been observed that with the increase of cement grade up to 400 kg/m3, the value of specific weight has increased from 2334 MPa to 2439 kg/m3, which is an increase of 4.4%. Based on the changes in compressive strength of 7 days for the creep tests in samples with different amounts of cement grade in the mixing plan, it has been observed that with the cement grade up to 400 kg/m3, the compressive strength value has increased from 21.9 MPa to 32.6 MPa, which is an equal growth with 48%. Based on the changes in compressive strength of 28 days for creep tests in samples with different amounts of cement grade in the mixing plan, it has been observed that with the cement grade up to 400 kg/m3, the compressive strength value has increased from 25.5 MPa to 39.3 MPa, which is a growth equal to with 52%.

Summary of results:

Based on the results of changes in specific weight based on changes in the type of test and grade of cement, it has been observed that the value of the results obtained for the parameter of specific weight of concrete obtained from sanding with increasing cement grade was higher than the values of in-situ and ultrasonic tests. Due to the sameness of the samples in in situ and ultrasonic tests, the amount of specific weight in these cases is equal to each other. In the cement grade of 400 kg/m3, the specific gravity value calculated in the creep test was higher than the results of the ultrasonic test and the in situ test. This is despite the fact that in the cement grade of 250 kg/m3, the results of the Core drilling test are lower than the results of the other two tests. Chart 12 shows the changes in 28-day compressive strength based on changes in the type of test and percentage of fibers. Based on the results of changes in 7-day compressive strength based on changes in the type of test and grade of cement, it has been observed that with the increase of cement grade, an upward trend has been recorded for 7-day compressive strength. The average compressive strength of 7 days in cement grade of 250 kg/m3 equals 20.1 MPa and in cement grade of 400 kg/m3 equals 30.8 MPa, which is an increase of 52%. Also, in all the tests, the compressive strength obtained in the Core drilling test was higher than the other results. The lowest recorded values were related to the ultrasonic test. For example, in the grade of cement 400 kg/m3, the value of compressive strength obtained in the grinding method is 7% and 11.3% higher than the method of in situ testing and ultrasonic testing, respectively. On average, the value of compressive strength obtained in 8% and 14% higher than the in situ test method and ultrasonic test, respectively. Based on the results of changes in 28-day compressive strength based on changes in the type of test and grade of cement, it has been observed that with the increase of cement grade, an upward trend has been recorded for 28-day compressive strength. The average compressive strength of 28 days in cement grade of 250 kg/m3 is equal to 25.2 MPa and in cement grade of 400 kg/m3 it is equal to 38.9 MPa, which is an increase of 54%. Also, in almost all the tests, the compressive strength obtained in the Core drilling test was higher than the other results. The lowest recorded values were related to ultrasonic testing in most of the samples. For example, in cement grade of 350 kg/m3, the value of compressive strength obtained in Core drilling method is 1% and 3% higher than in situ test and ultrasonic test, respectively. On average, the value of the compressive strength obtained in the Core drilling method is 1.9% and 2% higher than the in situ test method and the ultrasonic test, respectively. This shows that there is a certain difference between the different methods in the 28-day compressive strength. There is no and there was no particular dispersion in the recorded data.

Conclusions

Based on the specific gravity changes in the in-situ tests, it has been observed that by increasing the cement grade up to 400 kg/m3, the specific weight value has increased from 2360 MPa to 2418 kg/m3, which is an increase of 2.4%. For the ultrasonic test, the value of the specific gravity has increased from 2360 MPa to 2418 kg/m3, which is an increase of 2.4%, and for the waxing test, the value of the specific weight has increased from 2334 MPa to 2439 kg/m3, which is a growth of 4.4%. Regarding the 7-day compressive strength changes for in-situ tests in samples with different amounts of cement grade in the mixing design, it has been observed that with the cement grade up to 400 kg/m3, the compressive strength value has increased from 19.7 MPa to 30.5 MPa, which is an equal growth with 54%. The value of compressive strength for the ultrasonic test has increased from 18.8 MPa to 29.3 MPa, which is an increase of 56%, and for the wear test, the value of compressive strength has increased from 21.9 MPa to 32.6 MPa, which is a growth of 48%. In the 28-day compressive strength changes for in-situ tests in samples with different amounts of cement grade in the mixing plan, it has been observed that with the cement grade up to 400 kg/m3, the compressive strength value has increased from 24.6 MPa to 38.1 MPa, which is a growth equal to It is 55%. In the ultrasonic test, the compressive strength value has increased from 25.1 MPa to 39.2 MPa, which is an increase of 56%, and for the creep test, the compressive resistance value has increased from 25.5 MPa to 39.3 MPa, which is a growth of 52%.

Based on the results of changes in specific weight based on changes in the type of test and grade of cement, it has been observed that the value of the results obtained for the parameter of specific weight of concrete obtained from sanding with increasing cement grade was higher than the values of in-situ and ultrasonic tests. Due to the sameness of the samples in in situ and ultrasonic tests, the amount of specific weight in these cases is equal to each other. In the cement grade of 400 kg/m3, the specific gravity value calculated in the creep test was higher than the results of the ultrasonic test and the in situ test. This is despite the fact that in the cement grade of 250 kg/m3, the results of the Core drilling test are lower than the results of the other two tests.

Based on the results of changes in 7-day compressive strength based on changes in the type of test and grade of cement, it has been observed that with the increase of cement grade, an upward trend has been recorded for 7-day compressive strength. The average compressive strength of 7 days in cement grade of 250 kg/m3 equals 20.1 MPa and in cement grade of 400 kg/m3 equals 30.8 MPa, which is an increase of 52%. Also, in all the tests, the compressive strength obtained in the Core drilling test was higher than the other results. The lowest recorded values were related to the ultrasonic test. For example, in the grade of cement 400 kg/m3, the compressive strength value obtained in the sanding method is 7% and 11.3% higher than the in situ test and ultrasonic test, respectively. On average, the value of the compressive strength obtained in the Core drilling method is 8% and 14% higher than the in-situ test method and the ultrasonic test, respectively.

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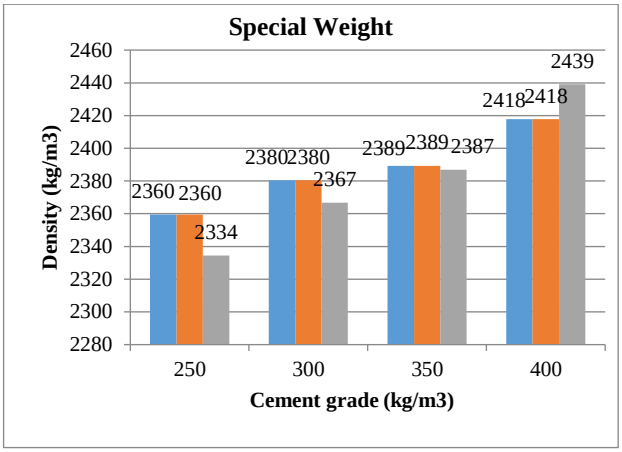

Figure 1: Changes in specific gravity based on changes in the type of test and grade of cement

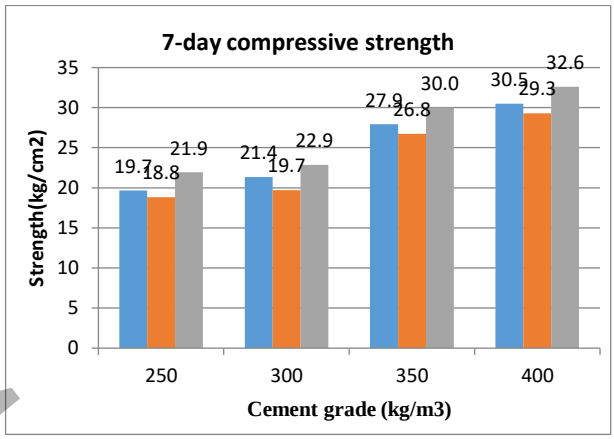

Figure 2: 7-day compressive strength changes based on changes in test type and cement grade

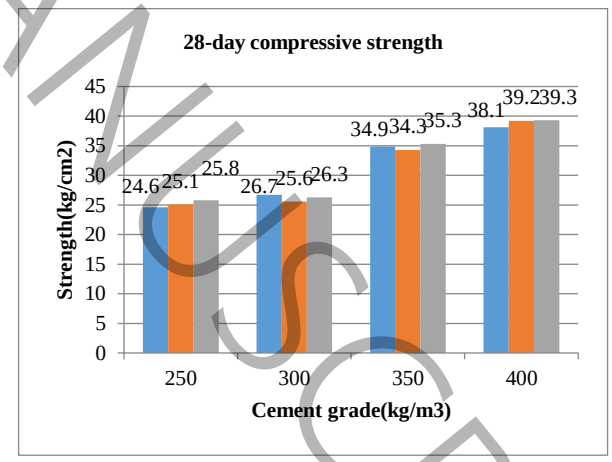

Figure 3: 28-day compressive strength changes based on changes in test type and cement grade

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