Investigation of Incorporation of two Waste Admixtures Effect on Some Properties of Concrete

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Investigation of Incorporation of Two Waste Admixtures Effect on Some Properties of Concrete

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Abstract

Study of the properties of concrete by adding two of the admixtures; iron splinters and minced rubber has been made to explore the concrete behavior with two curing periods 7 and 28 days. It has been taken into consideration in the present study the investigation of their effects on some properties of concrete, such as compressive strength, flexural strength and concrete densities. The admixtures were added in different percentage from cement content as a replacement of aggregates to concrete with mixing ratio of 1:1.5:3. The dry unit weights were decreasing with increasing percentage of the admixtures regarding to the reference concrete especially for admixture ratio of 5 and 10% from iron splinter and 5% of minced rubber respectively. It is concluded that the ratio of adding 10% from iron splinter and 5% of minced rubber admixture is supposed to be optimum percentage, that gives the highest compressive strength. This type of concrete which contain industrial wastes could be used in many types of concrete structures such as slabs, partitions, and platforms, as the test shows a significant development in strength of the concrete.

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Key words: Admixtures; compressive strength; flexural strength; ultra sonic; minced rubber; iron splinter.

1. Introduction.

The concrete is the firstly mostly used as building material in the world. Every year more than a cubic meter is produced per person worldwide.[14]. The easily procedure of transformed cement into functional shape makes concrete so popular in construction industry. Furthermore it is a low cost, low energy material made from the most available elements on earth. The molding ability of this material, its high compressive strength, and there are clearly considerable advantages in reducing its density.
However, to reduce the weight of structure use of lightweight waste admixtures as replacement of aggregate [7]. Admixtures are ingredients other than, aggregates, hydraulic cement, and fibers that are added to the concrete batch immediately before or during mixing. A proper use of admixtures offers certain beneficial effects to concrete, including improved quality, acceleration or retardation of setting time, enhanced frost and control of development strength, improved workability, and enhanced finish ability, [16]. The civil and environmental engineers have been challenged to convert the industrial wastes to useful building and construction materials,[5]. In recent years the construction industry has shown considerable interest in the utilization of waste. Several concentrations of the waste admixtures have been paid on this study with normal concrete in various proportions. Industrial wastes concrete admixtures, generally have two main categories; organic wastes like, wood sawdust, cork granular, coconut pith, and rice husks; and inorganic wastes like broken brick aggregate, silica gel, iron splinters, silica fume, minced rubber and chopped worn-out tires[4].

Hence, the aim of this study is to add combined mixture of industrial wastes to concrete ingredients and investigate their effects on some properties of concrete such as compressive strength by destructive and non-destructive tests (Ultrasonic method), flexural strength and concrete densities. The industrial wastes as combined admixtures included in this work are, iron splinters (scrap) and minced rubber were added in different percentage from cement content as a replacement of aggregates to concrete with mixing ratio of 1:1.5:3.

2. Experimental Works.

The experimental work is a part of the investigation has been planned in the following three stages. Preparation of materials, casting and testing of the specimens, as shown herein.

2.1. Materials.
2.1.1. Cement.

The cement used in this work was ordinary Portland cement produced by Tasloga factory in Sulymania. The chemical compositions and the physicals properties of this cement are shows in Tables-1 and 2. The results is compatible to the Iraqi specifications[12].

Table 1: Chemical compositions of the cement.

<table>
<thead>
<tr>
<th>Components</th>
<th>Results</th>
<th>Limits of No. 5/1984 Iraqi specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>CaO</td>
<td>60.1</td>
<td></td>
</tr>
<tr>
<td>SiO2</td>
<td>23.6</td>
<td></td>
</tr>
<tr>
<td>Al2O3</td>
<td>5.3</td>
<td></td>
</tr>
<tr>
<td>Fe2O3</td>
<td>4.54</td>
<td></td>
</tr>
<tr>
<td>MgO</td>
<td>4.33</td>
<td>Not more than 5 %</td>
</tr>
<tr>
<td>SO3</td>
<td>2.14</td>
<td>Not more than 2.5 %</td>
</tr>
<tr>
<td>Insoluble residue</td>
<td>1.28</td>
<td>Not more than 1.5 %</td>
</tr>
<tr>
<td>Loss on ignition</td>
<td>3.47</td>
<td>Not more than 4 %</td>
</tr>
<tr>
<td>Lime saturation</td>
<td>0.99</td>
<td>0.66-1.02</td>
</tr>
</tbody>
</table>
Table 2: Physicals properties of the cement.

<table>
<thead>
<tr>
<th>Properties</th>
<th>Results</th>
<th>Limits of No. 5/1984 Iraqi specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial setting time (minutes)</td>
<td>101 min.</td>
<td>Not less than 45 min.</td>
</tr>
<tr>
<td>Final setting time (hours)</td>
<td>311 min.</td>
<td>Not more than 10 h</td>
</tr>
<tr>
<td>Soundness</td>
<td>0.97</td>
<td>Not more than 1.0</td>
</tr>
<tr>
<td>Compressive strength at 3 days (MPa)</td>
<td>15.10</td>
<td>Not less than 15(MPa).</td>
</tr>
<tr>
<td>Compressive strength at 7 days (MPa)</td>
<td>23.78</td>
<td>Not less than 23(MPa).</td>
</tr>
</tbody>
</table>

2.1.2. Fine aggregate.

Al-Ukhaider wash natural sand was used to prepare concrete mixture in this investigations. The results indicated that this sand satisfied the Iraqi specifications[12].

2.1.3. Course aggregate.

The 5-19 mm wash natural crushed gravel was used. The results indicated that this Course aggregate is compatible to the Iraqi specifications[12].

2.2. Compression strength tests.

2.2.1. Destructive tests.

In this research two combined types of admixtures, minced rubber and iron splinter were used with different added percentages of 0%, 5%, and 15% from cement content. The proportion of mixing is taken as 1: 1.5: 3 with water cement ratio of 0.45 has been adopted, to maintain more or less same workability throughout the investigation. Ordinary Portland cement was used. It produced by Tasloga factory in Sulymania. Sixteen cubes of 1000mm³, and 16 prisms of 400mm x 100mm², were casted and tested after two curing periods 7 and 28 days investigate. The compressive and flexural tensile strengths were investigated. The variation of density is also tested for all the specimens. All results were compared with the reference concrete mixture (without additions) specimens.

The chemical and physical tests of the used cement were compatible with the Iraqi specification[9,12]. Al-Ukhaider washed natural sand was used, it is compliant to Iraqi specification [9,12] Washed natural crushed gravel of irregular shape and size 5-19 mm was used in this work. It indicates good conformance of the coarse aggregate to the limits of Iraqi specifications [1,12].

After mixing the weighted materials in a standard way and after completion of trial workability tests, the concrete has been placed in the standard metallic molds in three layers and has been compacted each time by tamping rod.

Flexural tensile strength has been determined under a standard loading frame using two point loading set up according to [6].

2.2. Nondestructive tests (Ultrasonic method).

Ultrasonic pulse velocity (UPV) is one of NDT. The method involves measuring the travel time over a known path distance of a pulse of ultrasonic waves.
The principle of this test is that velocity of sound in a solid material (the concrete with additives in this research) \( V \), is the function of the square root of the ratio of its modules of elasticity \( E \), to its density \( \rho \) as follow \([14]\):

\[
V = f \left[ \frac{g E}{\rho} \right]^{1/2} \quad (1)
\]

Where \( g \) is the acceleration. This relation can be used for the determination of the modules of concrete elasticity if Poisson’s ratio is known, and hence as a means of checking the quality of concrete.

The procedure of this test is that the apparatus generate a pulse of vibrations at an ultrasonic frequency which are transmitted by an electro-acoustic transducer held in contact with the surface of the concrete under test. After passing through the concrete, the vibration are received and converted to an electrical signal by a second electro-acoustic transducer, the signal being fed through an amplifier to a cathode-ray oscilloscope. The time taken by the pulse to travel though the concrete is measured by an electrical timing-unit with an accuracy of \( \pm 0.1 \) microsecond and, knowing the length of path travelled through the concrete, the pulse velocity can be calculated.

The pulses are introduced into the concrete by a piezoelectric transducer and a similar transducer acts as receiver to monitor the surface vibration caused by the arrival of the pulse. The relation between compressive strength and ultrasonic pulse velocity of concrete cubes of different mix properties is shown in figure-1.
3. Results and discussion.
3.1. The Density.

The unit weights of the concrete samples obtained from the experiment are given in Table-3, and Figure-2. The result shows that the dry density were decreasing with increasing percentage of the admixtures regarding to the...
reference concrete (without admixture reference concrete). This decreasing in unit weights varies with the admixture percent increasing and the highest density is with 5% iron splinter and 10% minced rubber which showed the maximum increasing of the density to about -0.307%, due to low density of minced rubber (as consider light weight and low density), as well as minced rubber with this percentage of admixture may conduct more pores and voids in the concrete specimens especially due to elongated shapes of the rubber cuttings.

Table 3: Dry density of the concrete with admixtures at 7 & 28 days curing period.

<table>
<thead>
<tr>
<th>No. of mix</th>
<th>Iron splinter %</th>
<th>Minced rubber %</th>
<th>Dry density at 7 days curing period (kg/m³)</th>
<th>Dry density at 28 days curing period (kg/m³)</th>
<th>Percentage of dry density variation for 28 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>2489.4</td>
<td>2534.8</td>
<td>------</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>5</td>
<td>2487.2</td>
<td>2535.4</td>
<td>+0.023%</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>10</td>
<td>2479</td>
<td>2527</td>
<td>-0.307%</td>
</tr>
<tr>
<td>4</td>
<td>10</td>
<td>5</td>
<td>2511</td>
<td>2554.8</td>
<td>+0.789%</td>
</tr>
</tbody>
</table>

Figure 2: Dry density of the concrete with admixtures at 7 and 28 days curing period.

3.2. Compressive strength.

There are many test methods to evaluate the strength of concrete. The choice of the test method depends on several factors such as structure access, cost of intervention, damage caused during the execution of the test, speed of execution, characteristics and type of assessment to be achieved, [11]. This research discusses the destructive test and the nondestructive test (ultrasonic test).

3.2.1. Destructive tests.

The results of compressive strength for the reference concrete and the concrete with various percent of admixtures using the destructive test by traditional method are presented in table 4, and figure-3.
Table 4: Compressive strength variation of concrete with different mixing ratios at both curing ages (7 & 28 days).

<table>
<thead>
<tr>
<th>Iron splinter %</th>
<th>Minced rubber %</th>
<th>Compressive strength at 7 days age (Mpa)</th>
<th>Percentage of compressive variation</th>
<th>Compressive strength at 28 days age (Mpa)</th>
<th>Percentage of compressive variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>18.42</td>
<td>---------</td>
<td>18.9</td>
<td>---------</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>18.80</td>
<td>+2.06%</td>
<td>20.55</td>
<td>+7.03%</td>
</tr>
<tr>
<td>5</td>
<td>10</td>
<td>15.35</td>
<td>-16.66%</td>
<td>18.7</td>
<td>-2.6%</td>
</tr>
<tr>
<td>10</td>
<td>5</td>
<td>20.30</td>
<td>+10.2%</td>
<td>26.25</td>
<td>+36.7%</td>
</tr>
</tbody>
</table>

Figure 3: Compressive strength of the concrete for different mixing ratio at 7 and 28 days age.

3.2.2. Nondestructive tests (Ultrasonic method).

The non-destructive testing (NDT) which estimates the strength of concrete without destroying the structure is the most practical and widely used.[13].

In the present study, ultrasound test was performed on all specimens. The pulse velocity was measured pressing the transducer to the core samples firmly.

The compressive strength of the concrete specimens was measured by breaking the concrete specimens. Results of this test are stated in Table-5. Figures-4 and 5, shows the correlation between the results obtained by the traditional test method and the ultrasound test for the two curing periods, respectively.

Table 5: Compressive strength of concrete with different mixing ratios at both curing ages using ultrasonic test.

<table>
<thead>
<tr>
<th>No. of mix</th>
<th>Minced rubber %</th>
<th>Iron splinter %</th>
<th>Compressive strength at 7 days age (Mpa)</th>
<th>Compressive strength at 28 days age (Mpa)</th>
<th>Percentage of compressive variation for 28 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>18.2</td>
<td>18.9</td>
<td>------</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>5</td>
<td>18.3</td>
<td>20.1</td>
<td>+6.34%</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>10</td>
<td>14.8</td>
<td>17.7</td>
<td>-6.35%</td>
</tr>
<tr>
<td>4</td>
<td>10</td>
<td>5</td>
<td>19.7</td>
<td>25.75</td>
<td>+36.24%</td>
</tr>
</tbody>
</table>
This study clearly indicates that with the ratio of 10% of iron splinter and 5% of minced rubber, gives the maximum value of compressive strength. It may be concluded that the ratio of adding 10% from iron splinter and 5% of minced rubber admixture is supposed to be optimum percentage. This type of concrete which containing industrial wastes could be used in many types of concrete structures such as slabs, partitions, and platforms, as the test shows a significant development in strength of the concrete[2,3].

Moreover, this study revealed that there is good and significant compatibility between the destructive and non-destructive test for compression strength for all admixture mixing ratio, and the determination factor between the two tests type is $R^2=0.993$ (Figures 6 and 7). This compatibility leads to fruitfully relation to use the relation in such studies and use the non-destructive test.
Figure 6: Compressive strength results from both destructive and non-destructive test for the different admixture mixing ratio.

![Compressive Strength Results](image)

Figure 7: Relationship between the destructive and non-destructive compressive strength results for different admixture mixing ratio.

![Relationship Between Strengths](image)

\[ y = 1.0224x - 1.0374 \]
\[ R^2 = 0.9932 \]

4. Flexural strength.

Flexural strength results of concrete samples for various additions of percentages of admixture are presented in table -6. Figures-8, illustrated the behaviour of flexural strength of concrete due to adding the combined industrial
waste admixtures with different percentage of iron splinter and minced rubber after 7 and 28 days curing periods, respectively. From the results revealed, it may be observed that with the increase in admixture the flexural strength was increased and afterwards it was decreased at the 5% of waste iron splinter and 10% of the waste minced rubber admixtures. Hence, it may be concluded that the 10% of iron splinter and 5% minced rubber admixtures is supposed to be optimum within the scope of present investigation. This is due to the increasing of bonds inside concrete and produced higher internal integrity. Regarding flexural strength also, it is observed that the above combination of concrete as discussed for compressive strength is supposed to yield optimum strength.

Table 6: Results of flexural strength of concrete with admixtures for both curing ages.

<table>
<thead>
<tr>
<th>Iron splinter %</th>
<th>Minced rubber %</th>
<th>Flexural strength at 7 days (Mpa)</th>
<th>Flexural strength at 28 days (Mpa)</th>
<th>Percentage of compressive variation for 28 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>3.82</td>
<td>6.07</td>
<td>------</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>4.12</td>
<td>6.4</td>
<td>+5.43%</td>
</tr>
<tr>
<td>5</td>
<td>10</td>
<td>3.25</td>
<td>4.9</td>
<td>-19.27%</td>
</tr>
<tr>
<td>10</td>
<td>5</td>
<td>4.54</td>
<td>6.8</td>
<td>+12.02%</td>
</tr>
</tbody>
</table>

Figure 8: Flexural strength of the concrete for different mixing ratio at 7 and 28 days age.

4.-Conclusions.

The technique used in this research provide us with valuable information, which will help us to understand the parameters in admixture effect on the concrete behavior. The usage of industrial waste admixtures such as iron splinter and minced rubber (as light weight) has proved to be quite satisfactory, and by adding combined materials such as iron splinter and minced rubber on concrete density behavior, showed higher density increasing (from normal concrete). In contrast, the admixture ratio of 5% of iron splinter and 10% minced rubber reduce the dry density to about 0.307%.

Also, the compressive strength of concrete made with admixtures is higher than the ordinary concrete. It increases to about 36% by adding 10% of iron splinter and 5% minced rubber, while it decreased with admixture ratio of 5% of iron splinter and 10% minced rubber. Hence this percentage replacement may be regarded as optimum dosage of the admixtures with respect to compressive strength.

However, This study revealed that there is good and significant compatibility between the destructive and non-destructive test for compression strength for all admixture mixing ratio, with determination $R^2=0.993$. This research has revealed that the flexural strengths with respect to adding 10% of iron splinter and 5% minced rubber admixture is found to be the highest value to about 12%.
References.


