THE EFFECT OF GYPSUM COMPENSATIVE ON MORTAR COMPRESSIVE STRENGTH

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ABSTRACT

The gypsum concrete is a new type of concrete and has its usage. This study aimed to know the effect of the gypsum on the compressive strength using 2 inch. or 50 mm cube specimen. They compensated 5%, 15% and 25% of the cement by the gypsum respectively for making six specimens for each treatment of the gypsum had been studied. Comparing their compressive strength at age (3) days and at age (7) days with a control mortar mix at the same ages.

The results shown that the compressive strength for cement mortar is decrease whenever the compensated 5%, 15% and 25% of the cement by the gypsum 38.8%, 60.5% and 68.5% respectively for (3) days age specimens. The compressive strength for cement mortar is decrease whenever the compensated 5%, 15% and 25% of the cement by the gypsum 38.1%, 58.4% and 66.1% respectively for (7) days age specimens. Through that we determined the limitation of gypsum concrete in building works.

Keywords: Mortar; Gypsum concrete; Compressive strength.

1. INTRODUCTION

Concrete has been the most common building material for many years. It is expected to remain so in the coming decades. Much of the developed world has infrastructures built with various forms of concrete.

Mass concrete dams, reinforced concrete buildings, prestressed concrete bridges, and precast concrete components are some typical examples. It is anticipated that the rest of the developing world will use these forms of construction in their future development of infrastructures.

In pre-historic times, some form of concrete using lime-based binder may have been used [Stanley, 1999], but modern concrete using Portland cement, which sets under water,
dates back to mid-eighteenth century and more importantly, with the patent by Joseph Aspdin in 1824.

Traditionally, concrete is a composite consisting of the dispersed phase of aggregates (ranging from its maximum size coarse aggregates down to the fine sand particles) embedded in the matrix of cement paste. This is a Portland cement concrete with the four constituents of Portland cement, water, stone and sand. These basic components remain in current concrete but other constituents are now often added to modify its fresh and hardened properties. This has broadened the scope in the design and construction of concrete structures. It has also introduced factors that designers should recognize in order to realize the desired performance in terms of structural adequacy, constructability, and required service life. These are translated into strength, workability and durability in relation to properties of concrete. In addition, there is the need to satisfy these provisions at the most cost-effective price in practice. [1]

2. CONSTITUENTS OF CONCRETE

The constituents of modern concrete have increased from the basic four (Portland cement, water, stone, and sand) to include both chemical and mineral admixtures. These admixtures have been in use for decades, first in special circumstances, but have now been incorporated in more and more general applications for their technical, and at times economic benefits in either or both fresh and hardened properties of concrete. [1]

3. PORTLAND CEMENT

In the past, Portland cement is restricted to that used in ordinary concrete and is often called Ordinary Portland cement. There is a general movement towards grouping all types of Portland cement, included those blended with ground granulated slag or a pozzolan such as fly ash (also called pulverized fuel ash), and silica fume into cements of different sub-classes rather than special cements. This approach has been adopted in Europe (EN 197–1) but the American practice places them in two separate groups (American Society for Testing and Materials provides for Portland cement under ASTM C 150 and blended cements under ASTM 595).

Raw materials for manufacturing Portland cement consist of basically calcareous and siliceous (generally argillaceous) material. The mixture is heated to a high temperature within a rotating kiln to produce a complex group of chemicals, collectively called cement clinker. Details of manufacturing process, the formation of these chemicals and their reactions with water are fully described in various textbooks (e.g., Chemistry of Cement and Concrete, 4th ed., Peter C. Hewlett, Ed). The name Portland originated from the similarity of Portland cement concrete to a well-known building stone in England found in the area called Portland. Portland cement is distinct from the ancient cement. It is termed hydraulic cement for its ability to set and harden under water.

Briefly, the chemicals present in clinker are nominally the four major potential compounds and several minor compounds (in small percentages, but not necessary of minor importance). The four major potential compounds are nominally (but actually impure varieties) termed as tricalcium silicate (3CaO.SiO$_2$), dicalcium silicate (2CaO.SiO$_2$), tricalcium aluminate (3CaO. Al$_2$O$_3$), and tetracalcium aluminoferrite (4CaO.Al$_2$O$_3$.Fe$_2$O$_3$). Cement chemists have abbreviated these chemical compounds to shorthand notations using
C≡CaO; S≡SiO$_2$; A≡Al$_2$O$_3$; and F≡Fe$_2$O$_3$. Historically, because of their impure state, the compound C$_3$S is referred to as “Alite;” C$_2$S as “Belite;” C$_3$A as the “aluminate” phase and C$_4$AF as the “ferrite (or iron)” phase. In practice, two cements of the same potential compound composition may not necessarily behave in the same manner during the fresh and hardened states of concrete.

The minor compounds of importance include the alkalis (sodium oxide and potassium oxide) and the amount of sulphate (mainly from added gypsum interground with clinker to prevent the violent reaction of tricalcium aluminate with the mixing water — flash set). [1-6]

The clinker is cooled output of the rotary kiln burning and grinding to a fine powder after addition of calcium sulfate dehydrate (CaSO$_4$.2 H$_2$O) known as (gypsum) and to control the freezing process of cement. The amount of gypsum necessary increases with the content (C$_3$A) and alkali in the cement as that increase fineness of cement lead to increase the surface area of the compound (C$_3$A) that interact in the early times, which means increasing the amount of gypsum required to prevent the flash setting of the cement paste.[7]

The amount of gypsum the added to the clinker expresses as a weight of a tri-sulfur dioxide SO$_3$ and British Standards (BS12: 1971) define this ratio by 2% when Max content (C$_3$A) of 7% and by 3% when more than content (C$_3$A) about 7%. [7]

Gypsum concrete, is one of concrete types that used for specified usage. Gypsum concrete is a building material used as a floor underlayment [8] used in wood-frame and concrete construction for fire ratings, [8] sound reduction, [8] radiant heating, [9] and floor leveling. It is a mixture of gypsum, Portland cement, and sand. [8]

4. MATERIALSand METHOD

4.1. Materials

4.1.1 Cement
Ordinary Portland Cement (OPC) ASTM Type I is used. The cement is compiled to Iraqi specification no.5/1999[10]

4.1.2 Fine Aggregate
Graded standard sand; The sand used for making test specimens shall be natural silica sand graded as in table(1).

<table>
<thead>
<tr>
<th>Sieve no.</th>
<th>Percent Retained</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>98 ± 2</td>
</tr>
<tr>
<td>50</td>
<td>75 ± 5</td>
</tr>
<tr>
<td>40</td>
<td>30 ± 5</td>
</tr>
<tr>
<td>30</td>
<td>2 ± 2</td>
</tr>
<tr>
<td>16</td>
<td>none</td>
</tr>
</tbody>
</table>

4.1.3. Mixing Water
Ordinary tap water was used in this work for all mixing proportions of the specimens.

4.1.4. Gypsum: (CaSO$_4$.2 H$_2$O)
4.2. Preparation of Specimens

Plate 1 show the six test specimens for each % of gypsum were dialed with, after 24 hours from the casting of them.

![Plate 1: The six test specimens for each % of gypsum were dialed with.](image)

All the works were in the concrete laboratory in the civil engineering department of Al-Anbar University. The temperature of the air in the vicinity of the mixing sled, the dry materials ' molds, base plates, and mixing bowl, shall be maintained between 20 and 27.5°C. The temperature of the mixing water shall not vary from 23°C by more than ±1.7°C. The relative humidity or the laboratory shall be not less than 50 percent. Preparation of specimen molds by applying thinly cover the interior faces of the specimen molds with mineral oil or right cup grease, remove excess oil or grease from the interior faces and the top and bottom surfaces of each mold. Apply a mixture of 3 parts of paraffin to 5 parts of rosin by weight heated at 110 - 120°C at the contact lines of the surfaces to get a watertight joints.

4.3. Composition of mortars

The proportions of materials for the standard mortar shall be one part of cement to 3 parts of graded standard sand by weight. Use a water cement ratio of 0.4 for a Portland cement.

The quantities of materials to be mixed at one time in the batch of mortar for making six test specimens for the control specimens shall be as in table (2).

<table>
<thead>
<tr>
<th>Gypsum%</th>
<th>Gypsum (g)</th>
<th>Cement (g)</th>
<th>Sand (g)</th>
<th>Water (ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>500</td>
<td>1500</td>
<td>200</td>
</tr>
<tr>
<td>5</td>
<td>25</td>
<td>475</td>
<td>1500</td>
<td>200</td>
</tr>
<tr>
<td>15</td>
<td>75</td>
<td>425</td>
<td>1500</td>
<td>200</td>
</tr>
<tr>
<td>25</td>
<td>125</td>
<td>375</td>
<td>1500</td>
<td>200</td>
</tr>
</tbody>
</table>

We compensative a 5%, 15% and 25% of the cement by the gypsum respectively for making six specimens for each % of the gypsum, we deal with in table (2).

Start molding the specimens with in a total elapsed time of not more than 2 min. and 30 Sec. after completion of the original mixing of the mortar batch. Allow the mortar to stand in the mixing bowel 90 Sec. without covering. During the last 15 Sec. this interval quickly scrape down into the batch any mortar that may have collected on the side of the bowl. Then remix for 15 Sec. at medium speed. Upon completion of mixing, the mixing paddle shall be shaken to remove excess mortar into the mixing bowl.
Place a layer of mortar about (25 mm) in all of the cube compartments. First layer was compacted by using a vibrating table not more than 10 Sec. When the vibrating of the first layer is completed, fill the compartments with the remaining mortar and then vibrate as specified for the first layer. Bring in the mortar that has been forced out onto the tops of the molds with a trowel and smooth off the cubes.

Place the test specimens in the moist closet or moist room from 20 to 24 hours with their upper surfaces exposed to the moist air but protected from dripping water, and then immerse the specimens in the water in storage tanks. Keep the storage water clean by changing as required.

4.4. Determination of compressive strength

The compressive strength was determined by using the digital hydraulic testing machine (ELE) with capacity of (2000) KN and rating of (0.98) KN/Sec.

Plate (2) the digital hydraulic testing machine (ELE) with capacity of (2000) KN and rating of (0.98) KN/Sec

Test the specimens immediately after their removal from storage water. All test specimens for a given test age shall be broken with the permissible tolerance prescribed as in table (3).

<table>
<thead>
<tr>
<th>Test Age</th>
<th>Permissible Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 days</td>
<td>± 1 h</td>
</tr>
<tr>
<td>7 days</td>
<td>± 3 h</td>
</tr>
</tbody>
</table>

Table (3): The permissible tolerance prescribed
Wipe each specimen to a surface - dry condition and remove any loose sand grains or incrustations from the faces that will be in contact with the bearing blocks of the testing machine. Test faces must be plane as possible.

Adjust the rate of load application so that the remainder of the load is applied, without interruption, to failure at such a rate that the maximum load will be reached in not less than 20 nor more than 80 Sec. from start of loading.

The average for three cubes was recorded for each age (3, 7) days respectively for compressive strength.

5. RESULTS AND DISCUSSION

Record the total maximum load indicated by the testing machine and calculate the average compressive strength for three specimens in (N/mm²) as shown in tables (4, 5).

The table (4) shows the stresses for the specimens in age (3) days. And the table (5) shows the stresses for the specimens in age (7) days.

The figures (1, 2) represent the relationship between the stress and the gypsum % compensated the cement for mortar strength for three specimens in (N/mm²).

The figure (1) shows the stresses for the specimens in age (3) days. And the figure (2) shows the stresses for the specimens in age (7) days.

Table (4) Mortar Compressive Strength for Test Age (3) days specimens

<table>
<thead>
<tr>
<th>%Gypsum</th>
<th>Stress(N/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>12.8</td>
</tr>
<tr>
<td>5% Gypsum</td>
<td>7.83</td>
</tr>
<tr>
<td>15% Gypsum</td>
<td>5.06</td>
</tr>
<tr>
<td>25% Gypsum</td>
<td>4.03</td>
</tr>
</tbody>
</table>

Fig (1) Age (3) days specimens Stress(N/mm²)
Table (5) Mortar Compressive Strength for Test Age (7) days specimens

<table>
<thead>
<tr>
<th>%Gypsum</th>
<th>Stress(N/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>21.21</td>
</tr>
<tr>
<td>5%Gypsum</td>
<td>13.12</td>
</tr>
<tr>
<td>15%Gypsum</td>
<td>8.82</td>
</tr>
<tr>
<td>25%Gypsum</td>
<td>7.2</td>
</tr>
</tbody>
</table>

6. CONCLUSIONS

1. The compressive strength for cement mortar is decrease whenever the compensated 5%, 15% and 25% of the cement by the gypsum 38.8%, 60.5% and 68.5% respectively for 3 days age specimens.
2. The compressive strength for cement mortar is decrease whenever the compensated 5%, 15% and 25% of the cement by the gypsum 38.1%, 58.4% and 66.1% respectively for 7 days age specimens.
3. In the other hand we can sense the effect of the cement mixing with the gypsum on strength development that can be usefully used in the gypsum board production to make it stronger.

7. REFERENCES

2. Stanley, C.C.1999, Concrete through the Ages, British Cement Association, Crow Thorne, Berkshire, UK.