

# Effect of “AERBETON” on the Mechanical and Physical Properties of Concrete

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**Abstract**— This study aims to use "AERBETON" which is an air entraining material added to the concrete mix to take advantage of its properties in construction in Gaza Strip.

Through this work, AERBETON, which is an air entraining material, was used as an additive to concrete mixture. The purpose is to study its properties when added to concrete before and after hardening, as well as comparing the results with concrete having the same ingredients but without adding this material.

In general, the test results has shown it is possible to add AERBETON by 5%, 10%, 15% of the weight of cement to the concrete mixture and so there is a change in the strength of concrete which becomes higher than that of normal concrete mixes.

As for the durability of concrete, samples of normal concrete and concrete containing the AERBETON air entraining material with different rates of 5%, 10% and 15% of cement weight have been prepared. The test of compressive strength at 7 and 28 days and through the results it showed that the durability of concrete gradually decreases when increasing the proportion of the added material to normal concrete.

In addition to this, the ratio of absorption of water of test samples was at its best percentage when adding 5% of the air entraining material by weight of cement. Moreover, among regular concrete mix results, it is shown that the percentage of absorbed water is less than normal concrete absorption and this shows the extent of resistance to moisture, salt water and sea water.

**Keywords**— Admixture, AERBETON, Air entraining material, Concrete

## I. INTRODUCTION

An admixture can be defined as a chemical product which, except in special cases, is added to the concrete mix in quantities not larger than 5 % by mass of cement during mixing or during an additional mixing operation prior to placing of concrete, for the purpose of achieving a specific modification, or modifications, to the normal properties of concrete.

Admixtures may be used in solid or liquid state. The latter is usual because a liquid can be more rapidly dispersed in a uniform manner during mixing of concrete. The admixtures can be added to the concrete at the plant during the mixing or at the job site before placing the concrete in form.

ACI Committee 212 lists 20 important purposes for which admixtures are used, for example, to increase the plasticity of concrete without increasing the water content, to reduce bleeding and segregation, to retard or accelerate the time of set, to accelerate the rates of strength development at early ages, to reduce the rate of heat evolution, and to increase the durability of concrete to specific exposure conditions, as well as to overcome certain emergencies during concrete operations.

The effectiveness of an admixture depends on several factors including: type and amount of cement, water content, mixing time, slump, and temperatures of the concrete and air. Sometimes, effects similar to those achieved through the addition of admixtures can be achieved by altering the concrete mixture: reducing the water-cement ratio, adding additional cement, using a different type of cement, or changing the aggregate and aggregate gradation.

One of these admixtures is the “Air Entraining admixture”. The use of air entrainment has been a common practice in concrete technology for more than 60 years. Air is intentionally entrained in the concrete mixture to reduce the potential for damage from freezing and thawing.

## II. RESEARCH AIM AND OBJECTIVES

### 2.1 The Aim

This work is directed towards establishing the use of air entraining in concrete mixtures and nonstructural elements. The successful use of air entraining will help in increasing the concrete resistance to humidity and salt water.

### 2.2 The Objectives

The objective of this research is to develop procedures for evaluating and qualifying air-entraining admixtures for use in cement in concrete. Three control mixes (5%, 10%

and 15%) were prepared to investigate the effect of air entraining on concrete properties.

To accomplish this objective, the following tasks were performed:

1. Information relative to the use of air-entraining admixtures in concrete was collected and reviewed. This information was obtained from performance, test methods, test data.
2. Test procedures currently used many countries for evaluating the effectiveness of air entraining admixtures were identified based on the information gathered in Task 1.
3. A detailed experimental research plan, which encompasses laboratory tests, was developed for evaluating the relative importance of the various factors affecting air entrainment identified in Task 1, modifying the test procedures proposed in Task 2, and validating the modified procedures.
4. The plan developed in Task 3 was executed. The plan included testing of fresh and hardened concrete properties. Also, a plan for putting the results of this research into practice was suggested.
5. A set of test procedures for evaluating air-entraining admixtures was developed based on the results of the entire research effort. For these test procedures were prepared in an (ASTM C 109-95) format.

### III. LITERATURE REVIEW

#### 3.1 Mechanism of Air Entrainment

Air bubbles are not formed by air-entraining agents (AEA), but stabilized by them. As the air-entraining agent molecules are inserted between adjacent water molecules at the water surface, the mutual attraction between the separated water molecules is reduced.

Lowering the surface tension stabilizes the bubbles against mechanical deformation and rupture, making it easier for bubbles to be formed. Without the presence of an air-entraining agent, the smaller bubbles, which have higher internal pressure, coalesce to form larger bubbles that have a greater tendency to escape to the surface and burst.

Absorbed AEA molecules at the surface of the bubble form a film, with their polar heads in the water phase. If the molecule is charged, the bubble acquires this charge. The electrostatic repulsion keeps bubbles separated and prevents coalescence (Dodson, 1990).

The ends of the AEA molecules that protrude into the water are also attracted to cement grains. This allows for a coating of calcium salts (i.e., products of cement hydration) to form around each air bubble, making it more stable than bubbles formed in plain water.

#### 3.2 Benefits of Admixtures

The reason for the large growth in the use of admixtures is that they are capable of imparting

considerable physical and economic benefits with respect to concrete. These benefits include the use of concrete under circumstances where previously there existed considerable or even insuperable difficulties. They also make possible the use of a wider range of ingredients in the mix.

Admixtures, although not always cheap, do not necessarily represent additional expenditure because their use can result in concomitant savings, for example, in the cost of labor required to effect compaction, in the cement content which would otherwise be necessary, or in improving durability without the use of additional measures.

It should be stressed that, while properly used admixtures are beneficial to concrete, they are not remedy for poor quality mix ingredients, for use of incorrect mix proportions, or for poor workmanship in transporting, placing and compaction.

#### 3.3 Effects of Air Entrainment on Properties of Concrete

##### 3.3.1 Effects on Fresh Concrete

The adherence of the entrained air bubbles to the cement particles reduces inter-particle friction between cement and aggregate grains. An increase in air content by 1/2 to 1 percentage point can increase the slump by about 2.54 cm (Whiting and Nagi, 1998), allowing a reduction in water needed to achieve the same slump. On the other hand, the attraction between bubbles and cement particles imparts a cohesion or "stickiness" to the concrete that makes it more difficult to place, consolidate, and finish, particularly at high air contents, and the compressibility of air can sometimes lead to problems in pumping.

##### 3.3.2 Effects on Hardened Concrete

An increase in air content leads to reductions in compressive strength, elastic modulus, and flexural strength. For example, increase in air content by a percentage point leads to average reductions of 2 to 6

Ratio	7 Days
Normal	<b>263</b>
(5%) admixture	<b>228</b>
(10%) admixture	<b>226</b>
(15%) admixture	<b>237</b>
5% admixture - 15 % water	<b>222</b>
10% admixture - 15 % water	<b>229</b>
15% admixture - 15 % water	<b>226</b>
(5%) admixture - 15 % - 15% water – 15% sand	<b>264</b>
(10%) admixture - 15 % - 15% water – 15% sand	<b>265</b>
(15%) admixture - 15 % - 15% water – 15% sand	<b>176</b>

percent in compressive strength, 3 to 6 percent in elastic modulus (in compression), and 2 to 4 percent in flexural strength (Whiting and Nagi, 1998).

Compressive strength reductions of 20 percent or more have been reported for concrete having normal air contents compared with design strength. In some cases, when Vinsol resin was replaced by non-Vinsol admixtures, the 28-day compressive strengths decreased for comparable air contents; a failure mode of mostly shear at the interface between aggregate and paste with very few fractured aggregate particles was noticed. Microscopic examination indicated accumulations of air voids around the aggregate particles that reduced the bond strength between the aggregate and surrounding mortar.

#### IV. TEST PROGRAM

##### 4.1 Material Properties

The materials used to develop concrete mixes in this study were air entraining admixture, coarse aggregate, and fine aggregate as well as cement as shown in Fig. 1.



Fig. 1: Materials for tests

##### 4.2 Compressive Strength Test

For each of the selected 6 admixtures, 10 different concrete mixes were prepared (60 mixes in total tested for compressive strength in accordance with ASTM C 109-95). Fresh concrete properties were determined for each mix. Compressive strength was determined at 7 and 28 days. The compressive strength ranged from 283 to 377 kg/cm<sup>2</sup>.

The average value of compressive strength of each control mix at various curing age is presented in Tables 1 and 2 and plotted in Fig. 2 and 3.

Table.1: Compressive Strength Test Results after 7 Days

Ratio	7 Days
Normal	263
(5%) admixture	228
(10%) admixture	226
(15%) admixture	237
5% admixture - 15 % water	222
10% admixture - 15 % water	229
15% admixture - 15 % water	226
(5%) admixture - 15 % - 15% water – 15% sand	264
(10%) admixture - 15 % - 15% water – 15% sand	265
(15%) admixture - 15 % - 15% water – 15% sand	176

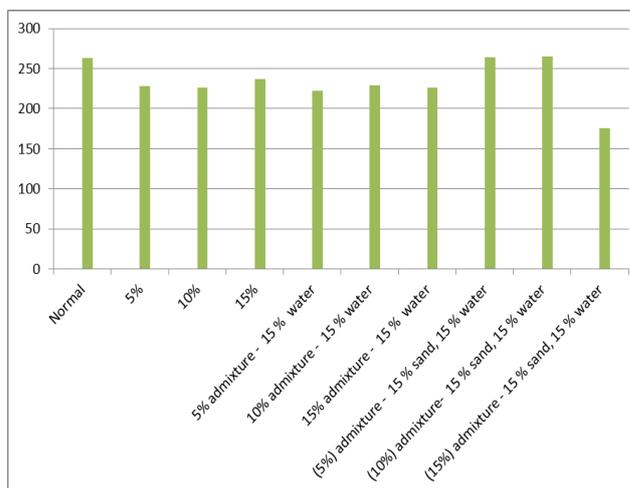


Fig. 2: Compressive strength test results after 7 days

Table.2: Compressive Strength Test Results after 28 Days

Ratio	28 Days
Normal	327
(5%) admixture	313
(10%) admixture	300
(15%) admixture	283
5% admixture - 15 % water	335
10% admixture - 15 % water	332
15% admixture - 15 % water	301
(5%) admixture - 15% water – 15% sand	377
(10%) admixture - 15% water – 15% sand	356
(15%) admixture - 15% water – 15% sand	335

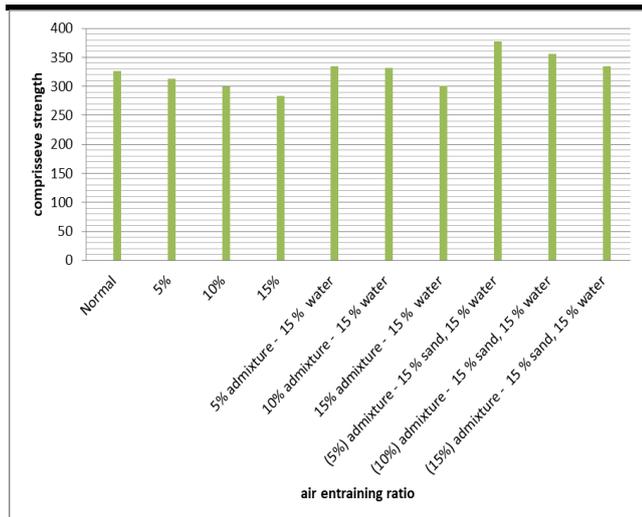


Fig. 3: Compressive strength test results after 28 days

4.3 Water Absorption Test

The water absorption was used as indication of mix water content for the best ratio. The water absorption value for control mix is shown in Table 3.

Table3: Water Absorption Test Results

Ratio	Dry weight (g)	Wet weight (g)	absorption %
Normal	7313	7728	5.7
5% Admixture	7135	7517	5.4

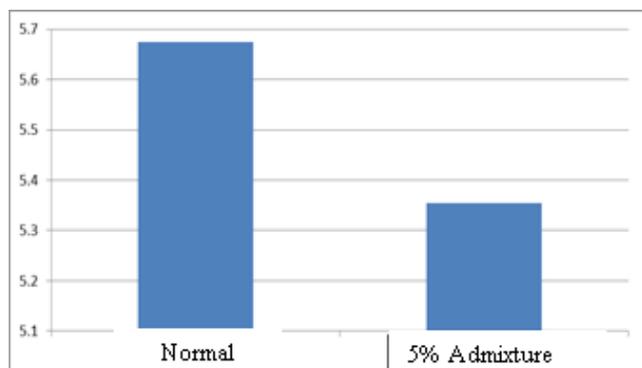


Fig. 4: Water absorption test results

4.4 Slump Test

The test measures consistency of concrete in a specific batch. It is performed to check consistency of freshly made concrete. Consistency refers to the ease with the test is popular due to the simplicity of apparatus used and simple procedure.

Unfortunately, the simplicity of the test often allows a wide variability in the manner in which the test is performed. The slump test is used to ensure uniformity of different batches of concrete under field conditions, and to ascertain the effects of plasticizers on their introduction.

The slump value was used as indication of mix workability. The slump values for different percentages of control mix are as shown in Table 4:

Table.4: Slump Test Results

Ratio	slump (cm)	Form of slump
Normal	6.5	Medium
5%	8.5	Medium
10%	9	Medium
15%	9	Medium

4.5 Density Test

In this research, the density of concrete cube specimens is the theoretical density. The density is calculated by dividing the weight of each cube by the cube volume.

The same cube specimens which are used to determine compressive strength were used to determine the density.

The average density values of control mixes at different curing ages are summarized in Tables 5 and 6 and presented in Fig. 5 and 6.

Table 5: Density Results after 7 Days

Ratio	Density after 7 days
Normal	2.47
5%	2.44
10%	2.44
15%	2.37
5% admixture - 15 % water	2.40
10% admixture - 15 % water	2.39
15% admixture - 15 % water	2.38
(5%) admixture -15% water – 15% sand	2.41
(10%) admixture -15% water – 15% sand	2.42
(15%) admixture -15% water – 15% sand	2.41

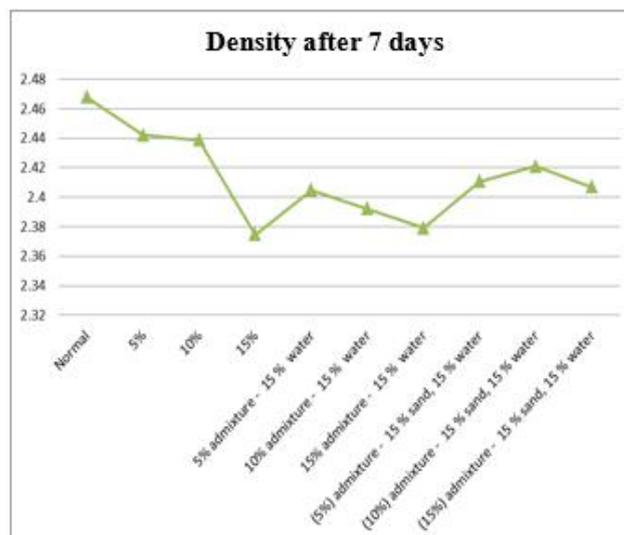


Fig. 5: Density results after 7 days

Table.6: Density Results after 28 Days.

Ratio	Density after 28 days
Normal	2.49
(5%) admixture	2.42
(10%) admixture	2.38
(15%) admixture	2.42
(5%) admixture - 15 % water	2.40
(10%) admixture - 15 % water	2.40
(15%) admixture - 15 % water	2.37
(5%) admixture -15% water – 15% sand	2.44
(10%) admixture -15% water – 15% sand	2.52
(15%) admixture -15% water – 15% sand	2.40

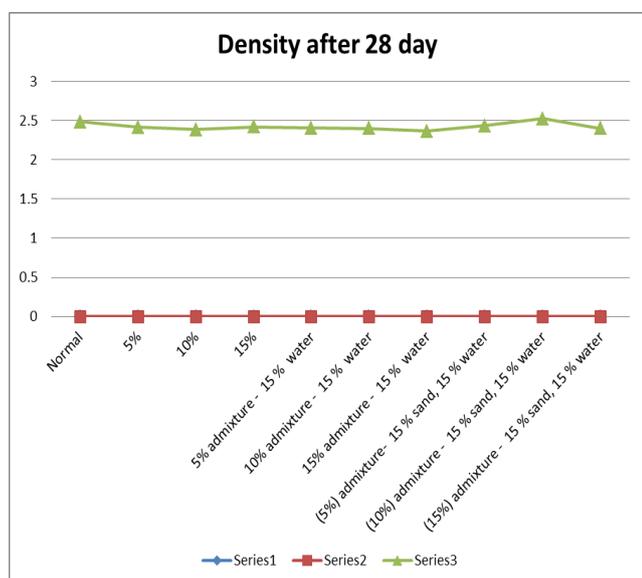


Fig. 6: Density results after 28 days

## V. RESULTS AND DISCUSSION

### 5.1 Conclusion

Concrete materials, concrete production procedures, construction practices, and field conditions affect, to varying degrees, the air-void system of concrete.

1. The type of air-entraining admixture has a statistically significant effect on the concrete air-void system.
2. Compressive strength decreases with increasing ratio of admixture.
3. Decrease of w/c ratio leads to increase of strength of concrete which leads to segregation and failure of compressive strength and reduces the workability.
4. AERBETON material increases durability, ensures higher resistance to frost and thaw as well as thawing salts.
5. The admixture reduces the density of concrete.
6. It improves the concrete pump ability.

7. Reduces shrinkage and bleeding.
8. Permits to reduce sand or fine component dosages.
9. The use of AERBETON permits to obtain a mix with volumetric and advantageous results.

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