J. Basic. Appl. Sci. Res., 2(5)5045-5051, 2012
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ISSN 2090-4304
Journal of Basic and Applied Scientific Research
www.textroad.com

Studying the Effects of Air Entrain Additive on Light Weight Perlite Concrete

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ABSTRACT

This paper presents the results of a laboratory study carried out on effect of using the simultaneous of microsilis and Air entrain additives on compressive strength of light weight perlite concrete. In this study, 63 test pecimens with different percentage and mixtures including microsilis and air entrain were used. 63 test specimens with different mixtures including microsilis were also prepared for comparison purposes. In the mixtures, lightweight Perlite Aggregate, microsilis, air entrain, cement type I, sand and water were used. Laboratory test results Showed that workability and compressive strength can be increased, and density of lightweight perlite concrete can be decreased by the use of air entrain and microsilis.However, the use of air entrain additive seems to be mandatory for the increase of workability and compressive strength of light weight perlite concrete. These results showed that concrete mixture incorporating 0.5% air entrain and 10% microsilis can be optimum case.

Key Words: Lightweight Concrete, Perlite, Microsilis, Air Entrain

1. INTRODUCTION

Today, lightweight concrete is used in building structural and unstructured elements in order to reduce dead load resulted from earthquake light weighting is the best scientific, practical and economical solution for reducing the earthquake disaster. It is clear that there is a direct relationship between light weight concrete strength and its weight[1,2]. Thus, reducing to the mass of structure or building is utmost important to reduce their risk due to earthquake acceleration. Also, reduction in the dead weight of a construction could result in a decrease in the cross-section of columns, beams, plates and foundations. [1,2].Concrete between 300 Kg/m^3 – 2000 kg/m^3 is called lightweight concrete compared with 2400 kg/m^3 special weight for common concrete [2,7].

As time passes, the traffic will be heavy in centre of large cities. Therefore, it is necessary to increase the width of the existing bridges. In such cases, the light weight concrete will be a powerful tool to be used. Because of this, there will not be any need to change the structural and foundation systems. According to favourite resistance of lightweight concrete against the fire, we can decrease the thickness of slabs little than recommended least amount in building codes. Transporting the prefabricated elements made of lightweight concrete is very easy and cheap too. The light weight concretes may be divided into three groups according to their composition[3]. a) Cellular concretes— made by incorporating air voids in a cement paste or cement-sand mortar, through use of either preformed or formed-in-place foam. These concretes weigh from 200 to 1200 kg/m^3. Numerous proprietary methods and agents are used to produce cellular concrete but essentially they can be considered in two groups: those using performed foam and those using formed-in-place foam. Formed-in-place foam is generated by special high speed mixing of water, foaming agent, cement and aggregates (if any) to allow foam to form in the mixer. Initially large air bubbles are reduced to a reasonably uniform size as mixing proceeds.

b) no-fine concretes— made by the exclusion of natural fine aggregate. These concretes weigh from 700 to 1500 kg/m^3.

c) Light weight aggregate concretes— made with lightweight aggregates such as lightweight expanded clay aggregate (Leca), expanded perlite or vermiculite aggregate, scoria, shale, slate, expanded polystyrene pellets. Density ranges from 800 to 1850 kg/m^3. In addition, light weight concretes may be divided into three groups according to their strength [1,3,4,5,6,9].:

a) Insulating lightweight concretes— these concretes have compressive strengths of 7 Mpa or less. The thermal conductivity depends on density, and then density of these concretes is limited to 800 kg/m^3 for achieved low thermal conductivity.

b) Structural light weight concretes— these concretes weigh from 1440 to 1840 kg/m^3 and have compressive strengths of 17 Mpa or more. The plasticity of concrete depends on density, and then there is a low limit density

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for these concretes. These concretes made with resistant and lightweight aggregates (medium) such as perlite, shale, slate, clay. Lightweight perlite aggregate was used in this study. The strength of lightweight concrete depends on density. But, use of heaviest lightweight aggregate doesn't increase the strength, inevitably.
c) Middle structural light weight concretes— these concretes weigh from 800 to 1440 kg/m^3. Compressive strengths of these concretes varied from 7 to 17 Mpa.
Products like prepared concrete, prepared gypsum, preparing mixed perlite with far in order to cover ceiling and preparing expanded perlite for floor are samples of employing perlite in building industry. [6,7,9,12].

2.Perlite and its properties:

Perlite is not a trade name, but a generic name for naturally occurring siliceous volcanic rock. Perlite is a volcanic glass containing more than 65 percent silicon-oxide. "Perlite" is derived from "perle" that is French word and its main is pearl. Chemical analysis of perlite showed that it has SiO_2 (69.8-73.5%), Al_2O_3 (12.5-13.7%), Fe_2O_3+TiO_2 (1.5-2.3%), CaO+MgO (3.1-5%), K_2O+Na_2O (5.5-7%), H_2O (2-5%)[2,7]. Perlite is a glass volcanic rock by riolite composition with 3-5 perecetn water, in temperature between 900-1100^{o}C, water is evaporated and leaving water from soft particles of perlite increase its volume 4-20 time, because of low weight and low thermal coefficient and also high acoustic absorption capability, expanded perlite is used in buildings and other industries[2].

Products like prepared concrete, prepared gypsum, preparing mixed perlite with far in order to cover ceiling and preparing expanded perlite for floor are samples of employing perlite in building industry [2]. Thermal conductivity of lightweight concrete is increased by using perlite instead of common Portland cement [2,7].

Expanded perlite can be manufactured to weigh from 32 kg/m3 to 240 kg/m3. This material, white or light grey in colour, is about 1/10 the weight of sand or gravel. The many, tiny glass-sealed cells in each particle of expanded perlite make it highly insulating as well as comparatively none-absorptive. Thus perlite mixes with about 30% less water than comparable lightweight aggregates [2,6,7,8,9,10,11,12].

3.MATERIALS AND METHODS

In this paper, two mixture groups were considered and were tested which each group has nine concrete mixtures. In group I microsilis additive and in group II microsilis and air entrain additives were used. Table 1 and 2 show the composition of the concrete mixtures produced and tested for group I and II, respectively. Seven trial mixes were made for each concrete mixture. The average density and compressive strengths of the concrete are presented in table 7 and 8 for group I and II, respectively. In this study 126 concrete specimens were made, totally. In the mixtures, lightweight perlite aggregate was used. The particle size distribution of expanded perlite is shown in table 3. Chemical compositions of microsilis and air entrain additives are given in table 4 and 5, respectively. In the mixtures, Portland cement Type I was used and its chemical compositions are given in table 6. Atmospheric vapour pressure curing method as a rapid curing method was used for curing of the concrete specimens.

Table 1 The Compositions of Concrete Mixtures (Group I)

Microsilis (%)	$\frac{W}{C}$	Perlite (kg)	Sand (kg)	Cement (kg)	Row
0	0.5	25	5	50	1
2	0.5	25	5	50	2
4	0.5	25	5	50	3
6	0.5	25	5	50	4
8	0.5	25	5	50	5
10	0.5	25	5	50	6
12	0.5	25	5	50	7
14	0.5	25	5	50	8
16	**0.5**	**25**	**5**	**50**	**9**

Table 2. The Compositions of Concrete Mixtures (Group II)

Air Entrain (%)	Microsilis (%)	$\frac{W}{C}$	Perlite (kg)	Sand (kg)	Cement (kg)	Row
0	0	0.5	25	5	50	1
0.1	2	0.5	25	5	50	2
0.2	4	0.5	25	5	50	3
0.3	6	0.5	25	5	50	4
0.4	8	0.5	25	5	50	5
0.5	10	0.5	25	5	50	6
0.6	12	0.5	25	5	50	7
0.7	14	0.5	25	5	50	8
0.8	**16**	**0.5**	**25**	**5**	**50**	**9**

Table 3. The Particle Size Distribution of Expanded Perlite

Used Percentages	Type of Perlite	Grading
40	R_1	0-0.15 mm
35	R_2	0.15-0.5 mm
0	R_3	0.5-1 mm
25	R_4	**1-2.5 mm**

Table 4. The Chemical Compositions of Microsilis Additive

Fe_2O_3	CaO	MgO	Al_2O_3	SiO_2	Chemical Compositions
0.4-2	2-2.3	0.1-0.9	1.7	85-95	(%)

Table 5. The Technical Characteristics of Air Entrain Additive

Density	Type of Material	Color
1.101 kg/lit	Active Surface Material	Light Yellow

Table 6 The Chemical Compositions of Cement

C_4AF	C_3A	C_2S	C_3S	Chemical Compositions
9-12	9-11	20-35	35-60	(%)

4.RESULTS AND DISCUTIONS

The average density and compressive strengths of the concrete are presented in table 7 and 8 for group I and II, respectively. The density - microsilis curve of mixtures for group I is shown in figure 1. The compressive strength - microsilis curve of mixtures for group I are shown in figures 2 and 3. The density - microsilis - air entrain curve of mixtures for group II are shown in figures 4 and 5. The compressive strength - microsilis - air entrain curve of mixtures for group II are shown in figures 6, 7, 8 and 9.

Table 7. The Density And Compressive Strengths of Concrete (Group I)

Compressive Strength (kg/cm^2)	Density (kg/m^3)	Microsilis (%)	$\frac{W}{C}$	Perlite (kg)	Sand (kg)	Cement (kg)	Row
150	1152	0	0.5	25	5	50	1
153	1159	2	0.5	25	5	50	2
158	1163	4	0.5	25	5	50	3
163	1171	6	0.5	25	5	50	4
179	1178	8	0.5	25	5	50	5
185	1189	10	0.5	25	5	50	6
188	1193	12	0.5	25	5	50	7
191	1210	14	0.5	25	5	50	8
194	**1222**	**16**	**0.5**	**25**	**5**	**50**	**9**

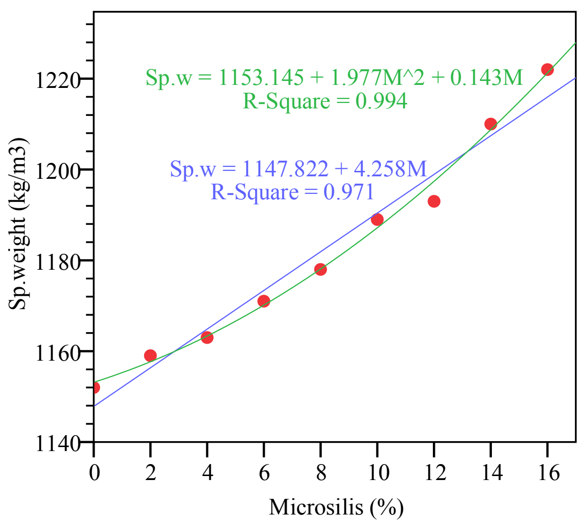

Figure1: Density vs. Microsilis

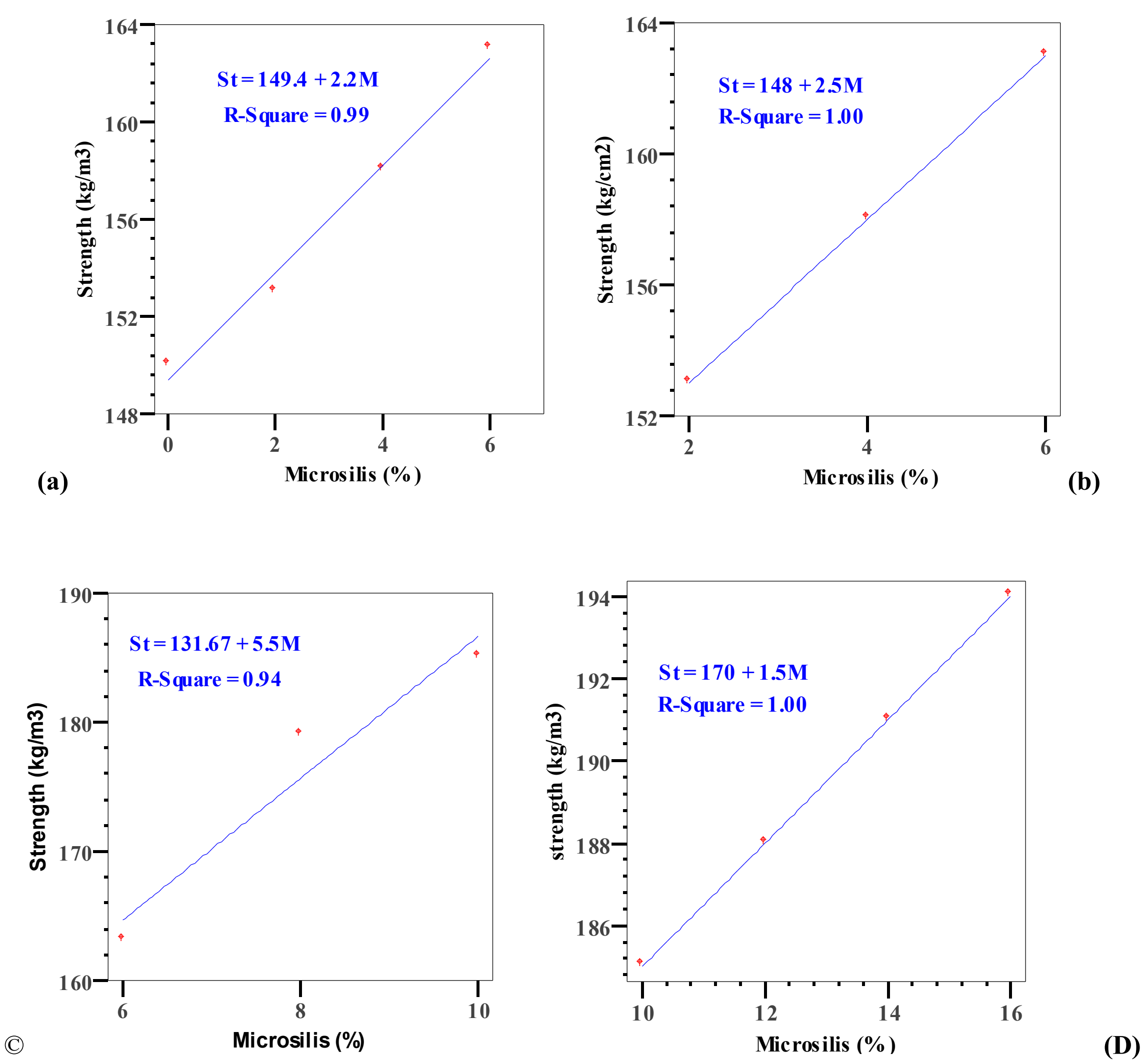

Figure3: Compressive Strength vs. Microsilis (a) 0-6%, (b) 2-6%, (c) 6-10%, (d) 10-16%

Table 8 .The Density And Compressive Strengths of Concrete (Group II)

Compressive Strength (kg/cm^2)	**Density (kg/m^3)**	**Air Entrain (%)**	**Microsilis (%)**	$\frac{W}{C}$	**Perlite (kg)**	**Sand (kg)**	**Cement (kg)**	**Row**
146	1150	0	0	0.5	25	5	50	1
154	1170	0.1	2	0.5	25	5	50	2
157	1175	0.2	4	0.5	25	5	50	3
160	1179	0.3	6	0.5	25	5	50	4
171	1185	0.4	8	0.5	25	5	50	5
186	1189	0.5	10	0.5	25	5	50	6
190	1197	0.6	12	0.5	25	5	50	7
193	1199	0.7	14	0.5	25	5	50	8
195	***1207***	***0.8***	***16***	***0.5***	***25***	***5***	***50***	***9***

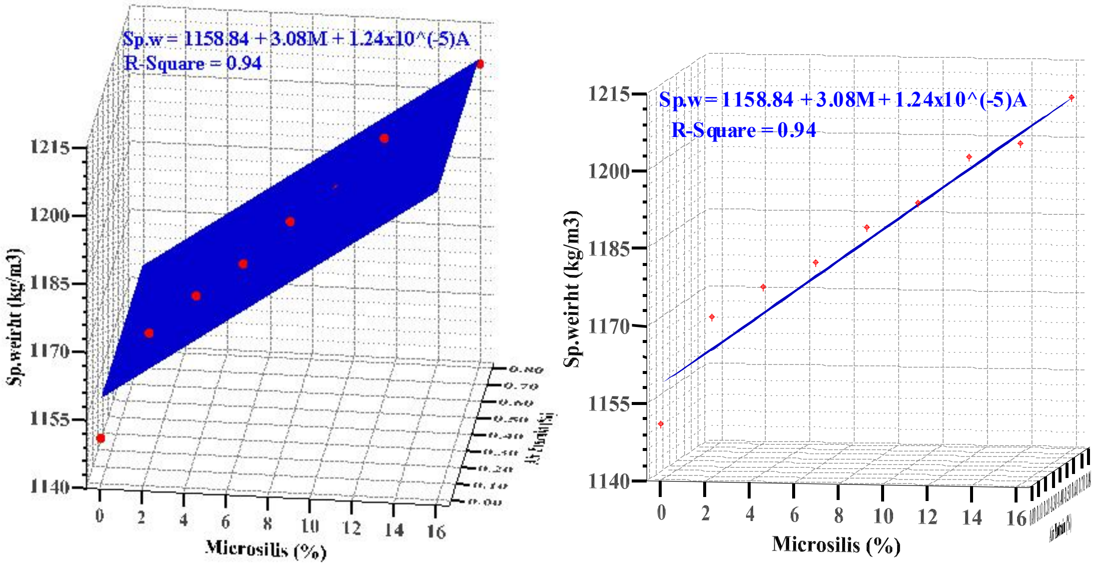

Figure 4: (a) Density – Microsilis – Air Entrain (b) side view

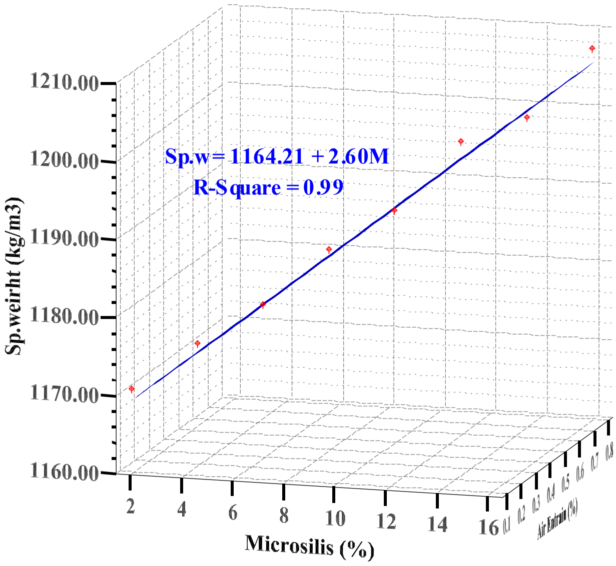

Figure5: Density – Microsilis (2-16%) – Air Entrain

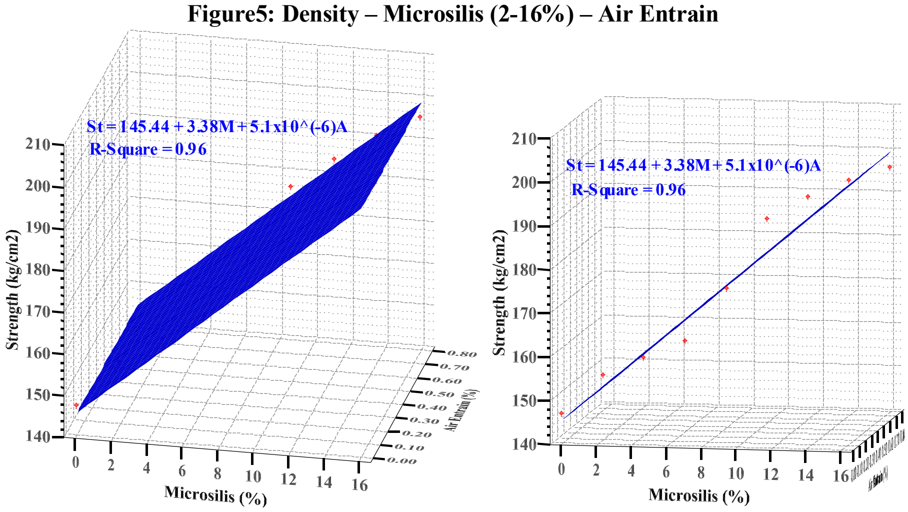

Figure6: (a) Compressive Strength – Microsilis – Air Entrain , (b) side view

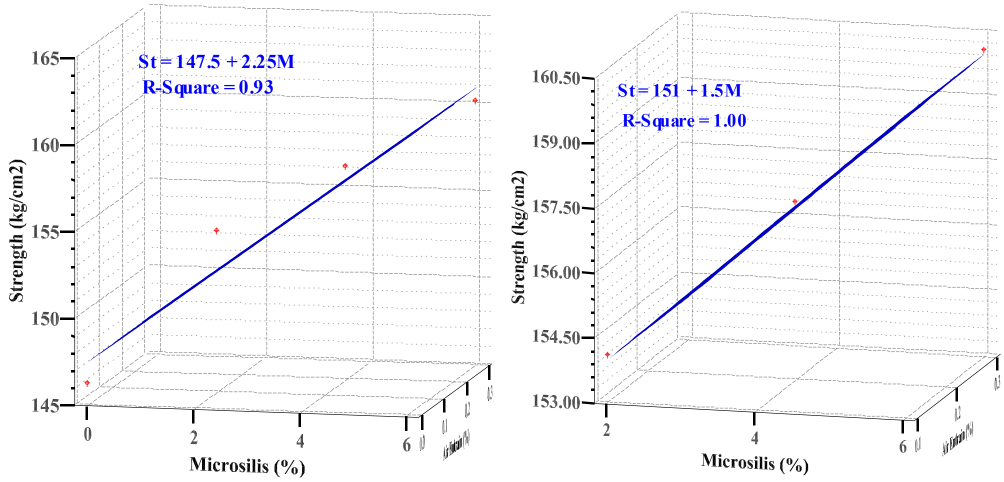

Figure7: Compressive Strength – Microsilis – Air Entrain , (a) 0-6%, (b) 2-6%

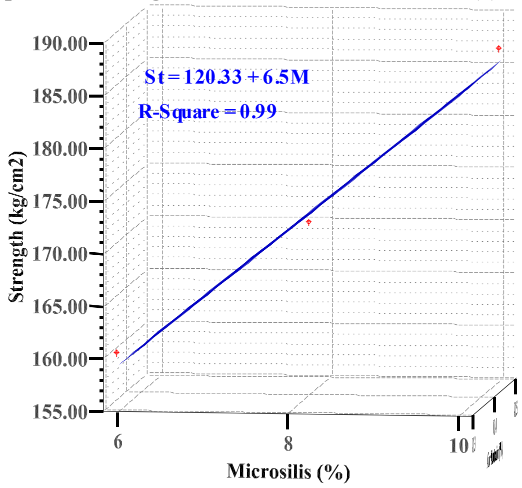

Figure8: Compressive Strength – Microsilis (6-10%) – Air Entrain

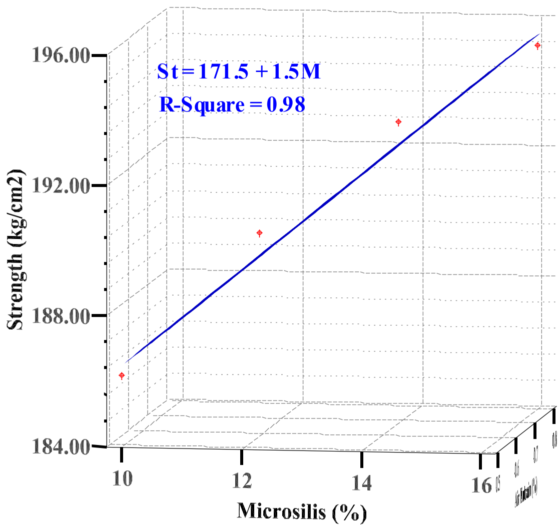

Figure9: Compressive Strength – Microsilis (10-16%) – Air Entrain

Table 7 and figures 1 and 2 shows that density and compressive strength gradually increased depending on the amount of microsilis. Figure 1 shows that density increased about 4.26 kg/m^3 per 1% increase in amount of microsilis. Figure 3(b), in the range of 2-6% microsilis, shows that compressive strength increased about 2.5 kg/cm^2 per 1% increase in amount of microsilis. Figure 3(c) and 3(d), in the range of 6-10% and 10-16% microsilis, respectively, shows that compressive strength increased about 5.5 kg/cm^2 and 1.5 kg/cm^2 per 1% increase in amount of microsilis, respectively. It can be seen that increase in amount of compressive strength in the range of 2-10% microsilis is greater than 10-16 % microsilis, and increase in amount of density in the range of 2-10% microsilis is lower than 10-16% microsilis. Then, it was concluded that the best results were obtained by using 10 percent of microsilis.

Table 8 and figures 4 and 6 shows that density and compressive strength gradually increased depending on the amount of microsilis and air entrain. Figure 5, in the range of 2-16% microsilis and 0.1-0.8% air entrain, shows that density increased about 2.6 kg/m^3 per 1% increase in amount of microsilis, and increase in amount of air entrain don't affect in density, actually. Figure 7, in the range of 2-6% microsilis and 0.1-0.3% air entrain, shows that compressive strength increased about 1.5 kg/cm^2 per 1% increase in amount of microsilis, and increase in amount of air entrain don't affect in compressive strength, actually. Figure 8, in the range of 6-10% microsilis and 0.3-0.5% air entrain, shows that compressive strength increased about 6.5 kg/cm^2 per 1% increase in amount of microsilis, and increase in amount of air entrain don't affect in compressive strength, actually. It can be seen that increase in amount of compressive strength in the range of 6-10% microsilis is 4.33 times greater than 2-6 % microsilis. Figure 9, in the range of 10-16% microsilis and 0.5-0.8% air entrain, shows that compressive strength increased about 1.5 kg/cm^2 per 1% increase in amount of microsilis, and increase in amount of air entrain don't affect in compressive strength, actually. It can be seen that increase in amount of compressive strength in this range is similar to 2-6% microsilis and is lower than 6-10% microsilis.

The comparison between results of concrete mixtures of group I and II show that use of simultaneous of microsilis and air entrain was increase the compressive strength and was reduce density. Because, 1% increase in amount of microsilis increased density about 4.26 kg/m^3 and 2.6 kg/m^3 in group I and II, respectively, which it is about 0.6 times of results of group I. It was also concluded that use of microsilis in the range of lower than 3% increased compressive strength, and decreased slightly in the range of 3-10% microsilis and didn't have any basically effect, actually. It was also concluded that use of microsilis in the range of 10-16% increased compressive strength. Since, this ideology was repelled that use of air entrain additive decreased the strength, usually. Since, the use of simultaneous of microsilis in the range of greater than 10% and air entrain in the range of greater than 0.5% was improved the results rather than use of microsilis, only.

5.CONCLUSION

Based on the results of the present experimental work, use of air entrain additive in lightweight perlite concrete mixtures didn't decrease compressive strength. It was concluded that the best results were obtained by using 10% microsilis and 0.5% air entrain. In this study water/cement ratio is permanent and we know that the compressive strength of concrete is depends on it. Since, it was expected that the use of air entrain lower water/cement ratios and raised strengths.

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