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Studying Mechanical Properties of Lightweight Concrete by the Effects of Masonry Mel Powder as Additive Percentage to Cement

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ABSTRACT

In recent years, with the increase of pollution problems of cement factories and its impact on the environment, there is always a great need to achieve high-strength structural lightweight concretes using local and inexpensive materials. To be sustainable development is also done. At present, an attempt has been made to use masonry powder to improve the mechanical properties of lightweight structural concrete. For this purpose, 180 cylindrical concrete specimens in dimensions of 15 x 30 with 25 types of mixing designs, including powdered concrete concretes with different selected times were considered. The results of this study, which was performed by performing the above tests on samples made in 7-day, 28-day and 90-day time, showed that the use of masonry powder at the rate of 18% of cement weight, while reducing the weight of concrete, increased strength has been. Concrete compression was 50% if microsilica was used and its compressive strength was increased by 30% if microsilica was not used.

Keywords:

Concrete, Mel powder, Light weight, Structure, Masonry.

1. Introduction

Masonry Mel powder consists of limestone powder and high percentage of calcium carbonate that is prepared industrially for certain building works. The use of these materials is regarded as very useful for their availability and their abundance in the mines of Iran, because they cheapen the cost of concrete and improve the mechanical properties of the concrete [1]. In recent decades much research has been conducted on concrete properties containing limestone powder such as compressive strength, setting time, slump, and viscosity [2-3] and significantly improves several cement properties such as compressive strength, water demand, workability, durability [8-14] and can also decrease production costs. There has been research on high-strength concrete using this powder [1, 4], there has been also another research on effect of Pozzolanic materials on durability and permeability of concrete against degradation and corrosion process caused by sulfate attack [5], however there is not any data about using masonry Mel powder effects on mechanical properties of concrete, particularly its effect on compressive strength and tensile strength [15]. The question was how the effect of Concrete depends on Mel powder. Experimental design technique was applied in order to evaluate these possible interactions. In the present study, we have tried to study and evaluate Pozzolanic material effect on the compressive and tensile strength of concrete using Azerbaijan indigenous materials practically and experimentally.

2. Materials and Methods

2.1. Materials

According to the fact that aim of implementing above tests is to achieve an optimum design to reduce surface cracks and reduce permeability and increase the durability of concrete and thus increase the compressive strength of concrete, Type II Sufian cements (Ordinary Portland Cement (OPC)) was selected for this study that are used in most construction projects. Because of some Pozzolanic materials that were not appropriate for mixed designs with other additives, the Pozzolanic cement was not used in these experiments. Its physical properties and chemical compositions are given in Tables 1 and 2

Table 1. Physical properties composition of OPC.

Specific gravity (g/cm3)	Specific surface area (cm2/g)	Setting time (hr.: min.)		Compressive strength (MPa)		
		Initial set.	Final set.	3d	7d	28d
3.15	3.280	3 : 41	6 : 01	22.6	31.6	38.7

Table 2. Chemical properties composition of OPC.

Chemical composition	Quantity (%)	Chemical composition	Quantity (%)
Cao	64.56	Sio_2	21.97
So_3	1.65	Al_2o_3	4.62
C_3s	50.68	Fe_2o_3	3.55
C_2s	24.76	Mgo	2.33

Tabriz drinking water was used for making concrete samples and also for curing made concrete that average analysis of physical and chemical parameters are as bellows. Its physical properties and chemical compositions are given in Table 3.

Table 3. Average analysis of physical and chemical parameters of Tabriz water.

Temperature (the sample)	Temporary hardness	Total hardness	Remaining dry	Chlorine residual	Electrical conductivity	Color	Tiff PH
93.55	61.80	6.0	54.211	7.11	1.38	0	40.728
Fluorine	**Phosphate**	**Ammonia**	**Nitrate**	**Nitrite**	**Bicarbonate**	**Carbonate**	**Sulfate**
65.48	21.39	58.35	6.5	0.04	8.465	6.254	35.195
Manganese	**Iron**	**Potassium**	**Sodium**	**Magnesium**	**Calcium**	**Dissolved oxygen**	**chloral**
0.0009	0.018	85.21	16.0	13.0	0.3	91.5	26.16

The results from the analysis of drinking water in Tabriz show that water has the standard quality needed for using in concrete mix design.

Perlite of volcanic glass rocks have Rhyolite composition that its 75% content is silicon oxide and trap 3 to 5 percent of the water in itself. Crude perlite has a specific gravity of 2.2 and its volume will increase 10 to 20 times after expansion and will have weight of 60 to 110 kilograms per cubic meter. Used perlite has been selected from Bostanabad area of East Azerbaijan province. Its physical properties and chemical compositions are given in Tables 4 and 5.

Table 4. Perlite Chemical analysis.

Chemical composition	Quantity (%)	Chemical composition	Quantity (%)
Mgo	0.35	Sio_2	71.88
Na_2o	3.93	Cao	1.26
K_2O	4.35	Al_2o_3	12.73
L.O.I	3.84	Fe_2o_3	0.96

Table 5. Perlite physical examinations.

Dissolution in water	Solubility in water	Melting Point (degrees)	PH	intensity	Specific gravity	Reduced Density
1.5	8%	529-589	Neutral	6-5	2.5	1041

Silica fume imparts very good improvement to rheological, mechanical and chemical properties. It improves the durability of the concrete by reinforcing the microstructure through filler effect and thus reduces segregation and bleeding. It also helps in achieving high early strength. Silica fume of specific gravity 2.34 was used in this study. Silica fume used in this study is Azna microsilica that its physical and chemical properties are compiled in Tables 6 and 7.

Table 6. Chemical analysis of micro silica.

Chemical composition	Quantity (%)	Chemical composition	Quantity (%)
Mgo	0.97	Sio_2	95.1
Cao	0.49	Al_2o_3	1.32
So_3	0.1	Fe_2o_3	0.87

Table 7. Physical analysis of micro silica.

Particle Size (microns)	Surface of particles (m/g)	PH	Specific gravity
0.05-0.15	20	9-10	4.1

Malialim A-20 that a commercially available poly carbonic acid base super plasticizer usually was used by 1.8% of a cement weight and was produced by BASF Company in Iran. Table 8 showed that general properties of it.

Table 8. Physical properties of super plasticizer.

Main component	Appearance	Solid content	Specific gravity	PH
Polycarbonic acid based compound	Dark brown liquid	20%	1.04· 0.02	2.5· 1.0

Micronized limestone with a high percentage of calcium carbonate with 2.3 specific gravity is prepared in stone stamping designs as powder that is provided by masonry Mel powder name that its chemical properties are compiled in table 9.

Table 9. Chemical analysis of masonry Mel powder.

Chemical composition	Quantity (%)	Chemical composition	Quantity (%)
Mgo	1.68	Sio_2	3.36
Cao	51.97	Al_2o_3	0.25
So_3	0.27	Fe_2o_3	1.1
K_2o	0.2	Na_2o	0.8
Co_2	40.23	L.O.I	39.67
-	-	Cl	0.008

2.2. Experimental Program

In this study sampling, aggregation, and determining the specific weight of aggregates were implemented according to the ASTM, D75, ASTM C136, and ASTM C29. In order to determine the water absorption of lightweight and normal aggregates, ASTM C127 regulation was used. Determining the compressive strength of light grains was implemented in Chang, Su [6] method. To determine compressive strength of lightweight grain of any aggregates, 50 grains were selected randomly. Compressive strength test was done on lightweight concrete mixtures. Recommendations contained in the regulation of ACI 211 [7] were used in Lightweight concretes

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mix design. In constructing concrete samples, 18 mix designs were used that contain water to fixed cement materials ratio of 0.4, masonry Mel powder to cement ratio of 0.00 , 0.05 , 0.06 , 0.07 , 0.08 , 0.09 , 0.10, 0.11 , 0.12 , 0.13 , 0.14 , 0.15, 0.16 , 0.17 , 0.18 , 0.19 , 0.2 and a coarse-grained perlite with maximum 12 cm dimension and fine-grained materials with a Fineness modulus of 2.6. Regulations of ACI 363R and ACI 211.4R-93 were used in order to estimate required water and to reduce required water when the consumption is high. To enhance the accuracy of test results, lightweight aggregates were saturated in water for an hour and then were prepared in Saturated Surface Dry form (SSD). The slump was measured and each mold for testing specimens was filled with successive layers and vibrated. They all remained in molds for 24 h, then demolded and stored in a curing room at a temperature of 20 ± 2°C and relative humidity of 90 ± 5% for 7 , 28 , 90 days. The materials used in each mix design are shown in Tables 10 and 11.

Table 10. The materials used in concrete mix design using the perlite aggregates - Series A.

Code	Cement	Silica Fume	sand	Gravel	Light Gravel	Super Plasticizer	W/C	Mel Powder
A1	450	50	365	457	273	9	0.4	0
A2	428							5
A3	423							6
A4	418							7
A5	414							8
A6	409							9
A7	405							10
A8	400							11
A9	396							12
A10	391							13
A11	387							14
A12	382							15
A13	378							16
A14	474							17
A15	369							18
A16	365							19
A17	360							20

Table 11. The materials used in concrete mix design using the perlite aggregates - Series B.

Code	Cement	Silica Fume	sand	Gravel	Light Gravel	Super Plasticizer	W/C	Mel Powder
B1	450	0	365	457	273	9	0.4	0
B2	428							5
B3	423							6
B4	418							7
B5	414							8
B6	409							9
B7	405							10
B8	400							11
B9	396							12
B10	391							13
B11	387							14
B12	382							15
B13	378							16
B14	474							17
B15	369							18
B16	365							19
B17	360							20

3. Results and Discussion

Based on the results of tests and by comparing mixed results in Table 13 and according to Figures 1 to 4 it was determined that trend of strengthening of cement paste during the acquisition process can be useful and can increase the total strength of cement by replacing and increasing the proportion of masonry Mel powder in concrete in the most efficient mode to 17% of cementitious materials 'weight. What is obvious is that adding masonry Mel powder has desirable effect on concrete compressive and Tensile strength and its reason is increase of the density of solid and better compaction of concrete and improvement of concrete paste properties.

-According to the Table 11 and Figure 1 it can be seen that in the optimal conditions cement strength will be increased by 50 percent using volumetric ratio of mixing masonry Mel powder to cement to 0.17 as well as using micro silica.

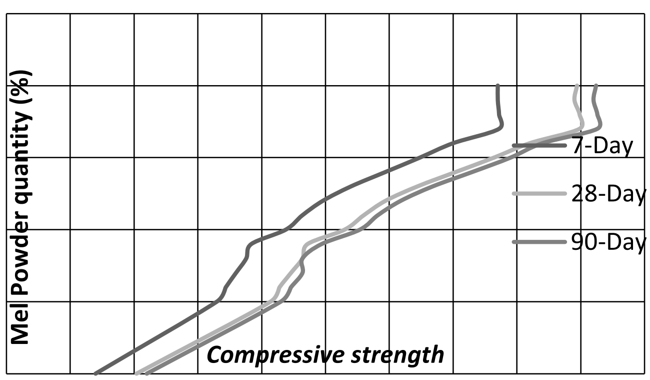

Figure 1. Compressive strength testing – with Mel powder (Code A).

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-According to the Table 13 and Figure 2 it can be seen that in the optimal conditions cement strength will be increased by 50 percent using volumetric ratio of mixing masonry Mel powder to cement to 0.17 without using micro silica.

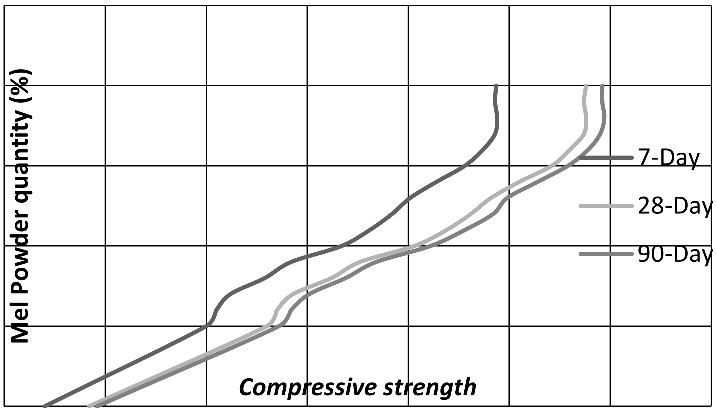

Figure 2. Compressive strength testing – without Mel powder (Code B).

-It was found that by checking the obtained results according to the graphs 3 to 4 and table10 tensile strength increase using micro silica by 50 percent and increase by 30 percent in the absence of micro silica as well as compressive strength based on proposed formula in Table 12.

Table 12: Tensile strength formula.

Reference	Tensile strength (MPa)
ACI 318-05 [16]	$f_{ct}= 0.85(0.55\sqrt{f_c'})$
Slate et al.[17]	$f_{ct}= 0.415\sqrt{f_c'}$
Result of this Paper	$f_{ct}= 0.469\sqrt{f_c'}$
f_c'= Compressive Strength	

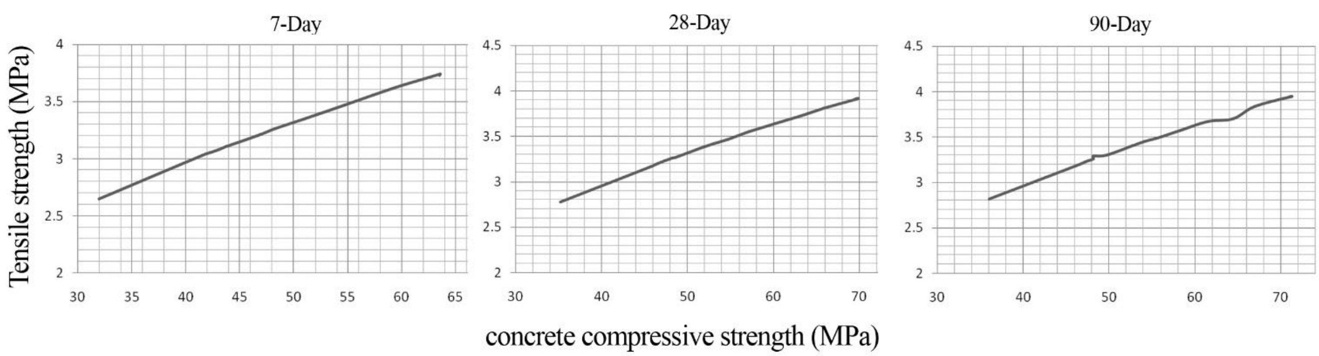

Figure 3. Comparison of concrete compressive & tensile strength (Code A).

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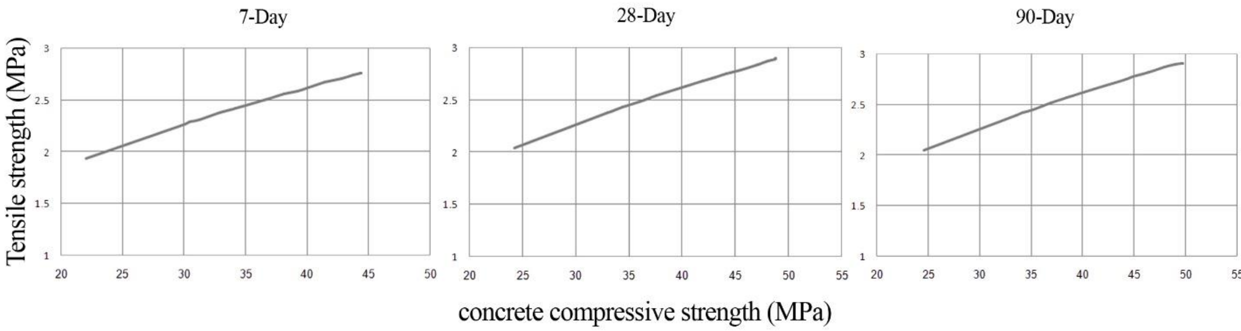

Figure 4. Comparison of concrete compressive & tensile strength (Code B).

Table 13. Results of Concrete compressive and tensile strength testing (MPa).

Code	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17
Compressive strength 7-days	32	41.5	42.2	43	43.8	44.2	46.9	48.2	49.8	52	54.7	57.4	60	63.6	63.6	63.5	63.5
Tensile strength 7-days	2.65	3.03	3.05	3.08	3.11	3.12	3.21	3.26	3.31	3.38	3.47	3.56	3.64	3.74	3.74	3.73	3.73
Compressive strength 28-days	35.2	45.7	46.4	47.3	48.2	48.6	51.5	53	54.7	57.2	60.2	63.2	66	69.9	69.9	69.5	69.7
Tensile strength 28-days	2.78	3.17	3.2	3.23	3.26	3.27	3.37	3.42	3.47	3.55	3.64	3.73	3.81	3.92	3.92	3.92	3.92
Compressive strength 90-days	36	46.5	47.3	48.2	48.2	49.7	52.7	54.1	55.9	58.4	61.5	64.5	67	71.3	71.3	71	71.2
Tensile strength 90-days	2.82	3.2	3.23	3.26	3.29	3.30	3.40	3.45	3.5	3.58	3.67	3.7	3.84	3.95	3.95	3.94	3.95
Code	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15	B16	B17
Compressive strength 7-days	22	30	30.5	31.2	32.9	34.2	36.7	38.1	39.2	40.1	41.4	42.8	43.7	44.3	44.4	44.3	44.35
Tensile strength 7-days	1.94	2.27	2.29	2.31	2.38	2.42	2.51	2.56	2.59	2.62	2.67	2.71	2.74	2.76	2.76	2.76	2.76
Compressive strength 28-days	24.2	33	33.5	34.3	36.2	37.6	40.3	41.9	43.1	44.1	45.5	47.1	48	48.7	48.8	48.7	48.8
Tensile strength 28-days	2.04	2.38	2.4	2.43	2.49	2.54	2.63	2.68	2.72	2.75	2.79	2.84	2.87	2.89	2.90	2.89	2.9
Compressive strength 90-days	24.6	33.6	34.3	35.1	36.9	38.4	41.1	42.8	44.2	44.9	46.4	47.9	48.9	49.5	49.7	49.6	49.6
Tensile strength 90-days	2.05	2.4	2.42	2.45	2.52	2.57	2.66	2.71	2.75	2.78	2.82	2.87	2.9	2.91	2.91	2.91	2.91

-Studying results of Table 10 and 11 it can be concluded that final cost of concrete and also concrete weight will be decreased by replacement of masonry Mel powder as part of consumed cement.

4. Conclusion

Mel powder addition considerably influences some characteristics of concrete, but this influence depends also on other factors.In order to study the effect of using masonry Mel powder as part of consuming cement in construction projects in lightweight structural cements with perlite aggregate, the results of 18 mix designs and 108 cylindrical concrete samples were considered in 30 * 15 sizes and results of the tests show that using masonry Mel powder to construct cement sample with lightweight perlite grains to 17 percent of cement weight will make proper compatibility, positive and significant effect on compressive and tensile strength, weight loss and reduce the cost of concrete and if micro silica is used in mix, this effect will be better.

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