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Article

Investigation of Physical Characteristics of Non-Structural Lightweight Aggregate Blocks

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Abstract: Today, the style of light construction materials used in building is one of the most important factors in reducing building's dead load and better performance of the structures in the earthquake. One of the ways to reduce the structure weight is to use lightweight blocks instead of using traditional materials. The main purpose of this research is to compare density, compressive strength and water absorption volume of non-load-bearing lightweight blocks made of natural and artificial lightweight aggregates. Scoria lightweight aggregates of Sanandaj, Ghorveh mine, pumice in Tabriz, Bostanabad mine, and Leca in Leca enterprise have been used to make the samples. Given the importance of the materials used, grading of coarse-grained materials has been conducted based on the standard of 7657 and grading of fine materials have been conducted based on the standard of 302.The experiments' results show that Scoria blocks due to hard texture, and high mechanical resistance of their lightweight aggregates, have had higher compressive strength, and density and lower water absorption volume compared to pumice and Lika lightweight aggregate blocks. Pumice blocks despite having desirable compressive strength and lower density compared to the two other blocks have higher water absorption volume, and do not meet the standard conditions. This same factor causes it faces with less interest. Among these Lika blocks with density of 1151.94 (kg per cubic meter) below 2000 kilograms per cubic meter of Iran density standard of 7782 (28-day compressive strength of 2.57 MPa), higher than 2.5 MPa of Iran compressive strength standard of 7782 (and water absorption volume of 282.92 kg per cubic meter) below 288 kilograms per cubic meter of Iran water absorption volume standard of 7782 (as a non-load-bearing lightweight block) have been diagnosed desirable.

Keywords: non-load-bearing lightweight blocks; lightweight aggregates; density; compressive strength; water absorption volume

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1. Introduction

Today, following numerous deadly earthquake around the world, engineers have found that light construction of the structures against the force by the earthquake force is one of the most scientific, practical and economical strategies for risk mitigation and damages caused by earthquake [1]. One of these ways is the use of new materials along with modern techniques in the building industry [2]. Production and use of lightweight concrete according to the development of high-rise building and the necessity of the use of lighting and retrofitting techniques has been caused, these materials are developing every day. Fortunately in our country large accumulations of lightweight aggregates have been identified. It is expected that more reserves can be exploited by continuing exploration works and develop the use of these materials [3]. Lightweight aggregates are grains have low spatial weight due to their porosity. They are used for the production of lightweight concrete, lightweight concrete blocks, and other lightweight building products [4]. Some lightweight aggregates are naturally available; the others are artificially produced [5]. Lightweight aggregates which are naturally formed often have volcanic origin like Pumice (Pumice stone), Scoria (pumice), volcanic ash, and tuffs. They have been created as a result of entering of lava to the water reservoirs

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such as seas and lakes and rapid cooling, which causes gas bubbles in minerals. But others, such as diatomite are sedimentary, and some of them such as metamorphic have also vermiculite origin [6].

Artificial lightweight aggregate production technology emerged with the increase of demand for using lightweight aggregate concrete and lack of easy access to natural aggregates. Artificial lightweight aggregates are produced in the following ways:

A. By heating and expansion of clay, shale, perlite slate, vermiculite, obsidian, and diatom shale.

B. By expansion of molten overhead of the molten metal furnaces by spraying controlled amounts of water with the help of water jet.

C. By industrial boiling produced by the ash of coal furnaces

D. By organic compounds such as polystyrene beehive [7].

The only method that is used in Iran is thermal expansion method for the production of clay, and expanded perlite, and yielding vermiculite [8].

Various types of lightweight concrete can be classified in three forms according to their production method, the first and most widely used way is to use porous aggregates with low bulk mass. The resulting concrete is called lightweight aggregate concrete. The second way is to create large holes in concrete ingredients or cement mortar. These holes should be clearly detected from super-fine bubbles due to bubbles forming. Concretes with the name of spongy concrete, porous concrete, foam concrete, and gas concrete are of this category. The third way is based on the removal of fine aggregates of firm concrete mixture called fine aggregate concrete [9]. According to the results of existing initial investigations, which have been done on natural lightweight aggregates of Scoria and Pumice, it seems that the use of these materials in the researches have had useful results. Binici [10] Furthermore, the effect of Pumice lightweight aggregates on resistance behaviors of lightweight aggregates concrete, the effect of these materials on the resistance of concrete mortar made of it, is also investigated in this study. Altun and colleagues [11] in a new act have investigated the resistance of lightweight aggregate concrete reinforced by steel fibers using the theory of neural networks. Gunduz [12] has investigated the resistance of lightweight aggregate concretes made of scoria, pumice and perlite. He has examined the results on non-load-bearing lightweight blocks. The results of Scoria and Pumice have been best results in this research. Moufti and Sabatan [13] while selecting scoria as resistant lightweight aggregate, carried out researches on compressive strength of concrete and mortar made with this lightweight aggregate molded in the laboratory. Their obtained results met the requirements of ASTM standard. Some studies in our country have also investigated the lightweight aggregates in Structural Lightweight Concrete. Zekavati and colleagues [14] have investigated the properties of lightweight aggregates of pumice and scoria in Structural Lightweight Concrete. They observed that the mechanical strength of lightweight aggregates clearly influence concrete compressive strength. Baghini and Karamuzian [15] to achieve high strength lightweight aggregate concrete concluded that since lika lightweight aggregate in Iran is often non-structural type, so it is better to use natural lightweight aggregate of volcanic origin. They also knew the use of filler in this type of concrete is inevitable. Among the few studies that specifically have assessed the non-structural lightweight aggregate concrete mix design is Shekariz and colleagues [16]. They have assessed the effects of non-structural lightweight concrete in sustainable development, microeconomic, and macroeconomic. Their results indicated that concrete wall is more expensive than brick wall. However, due to a significant decrease in the total weight of the structure, the amount of rebars, and concrete volume, more economical structure has been achieved totally. But unfortunately, no researches have been conducted on the physical properties of concrete and non-structural lightweight blocks (non-Load-bearing) based on Iran standard.

Given the importance of light construction in terms of better performance of structure, in earthquake and reduction of life and financial casualties as well as shortage of studies in this field, the present research have studied on building non-structural lightweight blocks using lightweight aggregates of scoria, pumice and lika. On the other hand density, compressive strength, and water absorption volume of these blocks have been investigated in this research. It should be noted that the present study has been conducted in the laboratory level but by considering workshop conditions and industrial consumptions. So perhaps more favorable results can be achieved without workshop conditions.

2. Research Methodology

2.1. Consuming materials

Cement: the use of different types of cements is allowed in the market. The type and amount of cement are determined based on the required properties, usage, and durability. Tehran Portland cement type II (in accordance with ASTM C595) with density of 3150 kilograms per cubic meter and chemical characteristics of Table 1, according to data quality control of this factory has been used in this research.

Table 1. Chemical characteristics of Portland cement type II Tehran

The chemical composition of cement	Percentage of constituents
SiO_2	21.5
Al_2O_3	4.2
Fe_2O_3	3.1
CaO	63.4
MgO	1.9
SO_3	3.7
Na_2O	0.84
L.O.I	1.9

Coarse-grained materials: natural and synthetic lightweight aggregates in lightweight aggregate concrete are used instead of coarse grains. Scoria of Sanandaj, Ghorveh mine with specific weight of 910 kilograms per cubic meter and grading curve of Figure 1 (in accordance with Table 2), as well as pumice of Tabriz, Bostanabad mine with the specific weight of 685 kilograms per cubic meter and grading curve of Figure 2 (in accordance with Table 3) have been used to make the samples of natural lightweight aggregates.

Table 2. Grading Test Specifications of Scoria of Sanandaj, Ghorveh mine

Sample weight: 728 kg		Specific weight: 910 kg per cubic meter			
Remained volume percent on the sieve in accordance with ISO 7657		Remained volume percent on the sieve	Remained percent on the sieve	remained weight on the sieve (g)	Sieve
Up limit	Low limit				
2	0	1.4	1.4	10	3.8
10	0	4.8	4.8	35	4
35	15	32.9	33.0	240	8
35	15	26.4	26.5	193	16
20	5	13.0	13.0	95	30
15	5	5.9	5.9	43	50
15	5	5.8	5.8	42	100
20	8	9.6	9.6	70	passing
				728	SUM

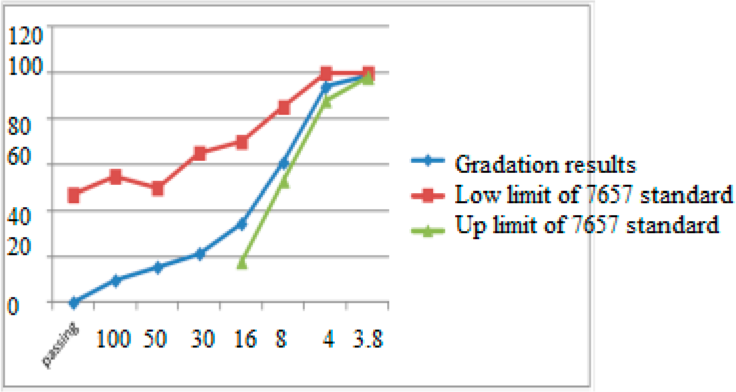

Figure 1. The diagram of grading Scoria of Sanandaj, Ghorveh mine.

Table 3. Grading Test Specifications of pumice of Tabriz, Bostanabad mine

Sample weight: 597 kg		Specific weight: 685 kg per cubic meter			
Remained volume percent on the sieve in accordance with ISO 7657		Remained volume percent on the sieve	Remained percent on the sieve	remained weight on the sieve (g)	Sieve
Up limit	Low limit				
2	0	0.8	0.8	5	3.8
10	0	2.5	2.5	15	4
35	15	30.6	31.2	186	8
35	15	23.8	24.3	145	16
20	5	10.5	10.7	64	30
15	5	7.9	8.0	48	50
15	5	8.9	9.0	54	100
20	8	13.2	13.4	80	passing
				597	SUM

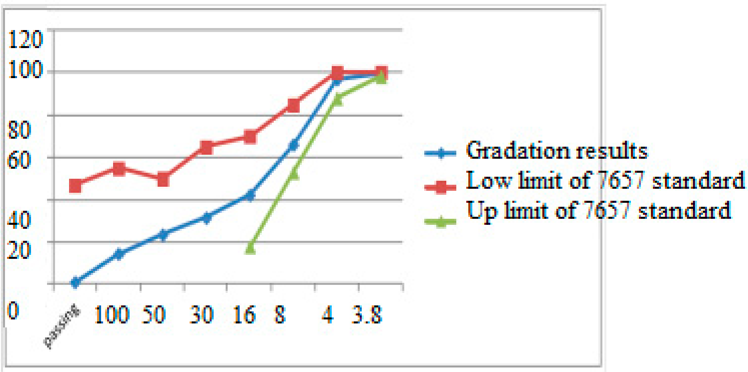

Figure 2. The diagram of grading of pumice of Tabriz, Bostanabad mine.

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Table 4. Grading Test Specifications of Lika of Lika Company

Sample weight: 487 kg		Specific weight: 475 kg per cubic meter			
Remained volume percent on the sieve in accordance with ISO 7657		Remained volume percent on the sieve	Remained percent on the sieve	remained weight on the sieve (g)	Sieve
Up limit	Low limit				
2	0	0.8	0.8	4	3.8
10	0	2.4	2.4	12	4
35	15	28.8	29.3	143	8
35	15	20.6	20.9	102	16
20	5	12.3	12.5	61	30
15	5	6.4	6.5	32	50
15	5	9.6	9.8	48	100
20	8	17.1	17.4	85	passing
				487	SUM

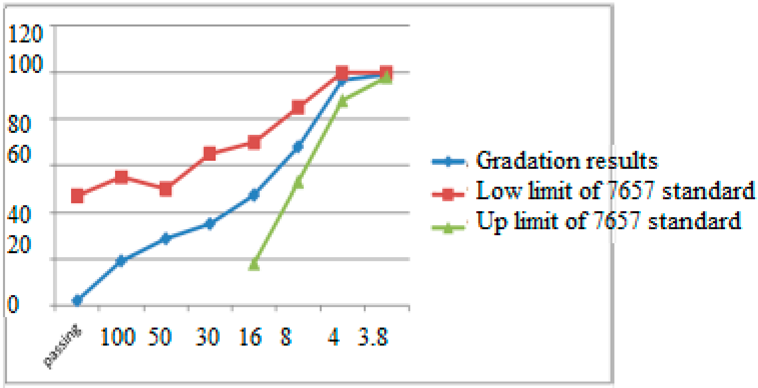

Figure 3. The diagram of grading of Lika of Lika Company.

As is clear, all grading curves are consistent with the standard of 7657 [17]. In addition the chemical properties of consuming lightweight aggregates have also been in Table 5.

Table 5. Chemical properties of consuming lightweight aggregates

Percentage of Lika compounds	Percentage of pumice compounds	Percentage of Scoria compounds	Chemical compounds
66.05	48.37	53.78	SiO_2
16.57	12.49	13.59	Al_2O_3
7.20	8.07	7.88	Fe_2O_3
3.46	8.43	8.51	Cao
1.99	9.58	5.16	MgO
0.69	4.64	3.59	Na_2O
2.69	3.27	3.17	K_20
0.04	0.31	-	SO_3
0.78	1.78	1.82	TiO_2
0.21	1.79	1.54	P_2O_3
0.11	0.11	0.19	MnO
-	0.60	-	L.O.I

It is worth noting, lightweight aggregates due to their cellular structure, can absorb more water than aggregates with normal weight. According to ASTM C127 standard (Water absorption test defined in 24 hours) [18], lightweight aggregates depending on their pores' system usually absorb

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water between 5 to 25 mass percent of dry aggregate. In contrast, most aggregates with normal weight absorb moisture less than 2 percent. However, the amount of moisture in a normal weight aggregate depot may increase to 5 to 10 percent or more. The important difference is that the amount of moisture in lightweight aggregates is absorbed into the grains, as well as on the surface, while the moisture in the normal weight aggregates is mostly surface moisture. This difference is important in the proportion of mixture, batching. Water absorption rate in lightweight aggregates is also a factor that affects the contribution of concrete mixture, and depends on the characteristics of the pores of aggregate. Water that is absorbed internally in lightweight aggregate is not immediately available for cement and should not be considered as mixing water. On the other hand, almost all the moisture in natural sand may be surface moisture, and thus is part of the mixing water [19].

That is why the need to determine the average amount of water absorbed by the lightweight aggregates is determined.

Table 6. The water absorption of natural and synthetic lightweight

24-hour water absorption	Substance
17	Scoria Lightweight
28	Pumice Lightweight
16	Lika Lightweight

Fine materials: natural sand used to make the samples is sand with broken format with a density of 2320 kilograms per cubic meter and fineness modulus of 3.39, 24 hours water absorption of 3% and chemical characteristics of Table (9). Grading Curve of this sand figure (4) has been in accordance with Table 7. On the other hand because of better fineness modulus and higher resistance that silica sand has compared to natural sand, it has been also used to make samples. The used silica sand is Qazvin silica sand with a density of 2150 kilograms per cubic meter, and fineness modulus of 1.50, and 24-hour water absorption of 23%, and chemical characteristics of Table (9). Grading curves of this sand has been in Figure (5) according to the Table (8).

Also standard fineness modulus has been defined 1.3 to 3.2. Sand production is not possible with this number, unless the laboratory production that is costly. So the experiments have been conducted based on the fineness modulus of 3.39 that is an acceptable number according to past researches.

Table 7. Grading Test Specifications sand under the mandatory standard

dry weight of material with container: 1266 kg			Container weight: 586 kg	Dry weight of sample: 681 kg		
Passespercent of the sieve in accordance with ISO 302		Passes percent of the sieve	Total remained percent on the sieve	Remained percent on the sieve	remained weight on the sieve (g)	Sieve
Up limit	Low limit					
100	100	100.0	0	0	0	5.16
100	89	98.5	1.5	1.5	10	4
100	60	69.3	30.7	29.2	199	8
90	30	43.8	58.2	25.6	174	16
45	15	29.2	70.8	14.5	99	30
40	5	14.4	85.6	14.8	101	50
15	0	6.2	93.8	8.2	56	100
-	-	2.6	97.4	3.5	24	200
-	-	0	100.0	2.6	18	200p
					681	SUM
					3.39	FM

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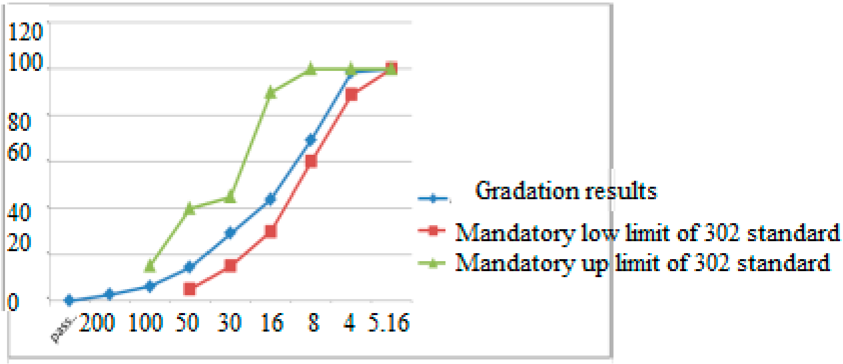

Figure 5. The diagram of sand under the mandatory standard.

Grading curve of sand becomes out from optional range defined in the standard of 302 (characteristics of concrete aggregates) [20]. So the compulsory range has been considered, which is broader.

Table 8. Grading Test specifications of silica sand

dry weight of material with container: 798 kg			Container weight: 214 kg		Dry weight of sample: 584 kg	
Passes percent of the sieve in accordance with ISO 302		Passes percent of the sieve	Total remained percent on the sieve	Remained percent on the sieve	remained weight on the sieve (g)	Sieve
Up limit	Low limit					
		100.0	00.0	00.0	0	5.16
		100.0	00.0	00.0	0	4
		100.0	00.0	00.0	0	8
		100.0	00.0	00.0	0	16
		91.3	8.7	8.7	51	30
		23.3	76.7	68.0	397	50
		5.8	94.2	17.5	102	100
		1.2	98.8	4.6	27	200
		00.0	100.0	1.2	7	200p
					584	SUM
					1.8	FM

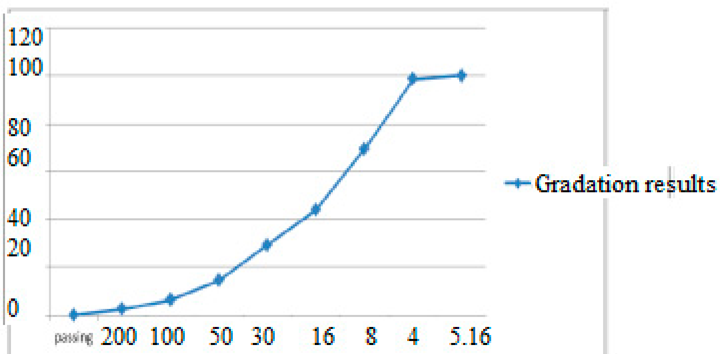

Figure 6. The diagram of silica sand.

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Water: Drinking water is generally can be used in making concrete, because its impurities are low. Excessive Impurity of mixing water not only affects the time consuming and the ultimate strength, but also may cause efflorescence, soiling, and the corrosion of bars, volume instability, and reduction of concrete durability [21]. Drinking water has been used in this study.

Table 9. Chemical characteristics of natural sand roving round of Forbat and Qazvin silica sand

Percentage of Silica sand	Percentage of Natural sand	Chemical compounds
95.8	95.3	SiO_2
2.15	1.91	Al_2O_3
0.35	0.64	Fe_2O_3
0.18	0.20	CaO
0.11	-	MgO
1.1	0.91	K_2O
0.28	0.15	Na_2O
0.11	0.32	TiO_2
-	0.47	L.0.I

Super Lubricants: Consumption of these additives increases the fluency of concrete, and can reduce the amounts of water consumed in concrete. So that concrete fluency remains constant and the compressive strength of concrete is increased. Super lubricant of Fiton Company with the technical characteristics in accordance with the Table (10) according to the catalog has been used to make samples.

Table 10. Super lubricant of Fiton technical characteristics

Liquid	Physical state
dark brown	Color
1.13+0.01 grams per cubic centimeter	Special Weight
12 months away from frost and direct sunlight	Time and storage conditions
Does not have	Chloride ion
ASTM C494M-04 Type G	Standard
20 liter plastic gallon	packing

2.2. Mix design

Volume method has been used to determine the mix design. In this way the volume of volume of freshly prepared concrete is considered equal with the summation of absolute volume of cementitious materials, aggregates, effective water, trapped air, and other additives. Determining the mixing ratio using this method requires determining the amount of water absorption and density of aggregates with different sizes [22].

The practical method is in the way that at first gradation curve of aggregates mixture has been determined. Then the weight of each of them has been determined by adoption of the specific values for cement content (quality of cement), water-cement ratio, the percentage of additives, super lubricant. And then the remaining empty space that must be filled by a mixture of aggregates has been calculated, and according to the volume percentage of each group of lightweight aggregates of scoria, pumice, lika, and sand, their weight has been achieved using the density of aggregates.

The amount of cement has been controlled to ensure proper performance, durability and continuity, shrinkage, creep and heat of hydration during hardening the risk of cracking. In addition lightweight aggregates due to lightness, desire to be detached from the other components of the concrete mixture. Whatever the slump of concrete is more, the possibility of detachment will be more.

Silica sand with a lubricant has been used to fix this problem. The same mixing method has been intended in order to unify the conditions for making samples and increasing the accuracy of the results of experiments. In this way, at first the lightweight aggregates of scoria, pumice, and lika for 30 minutes with two-thirds water have been poured into mixer-type blender to reach saturation

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mode. After this time the sand has been added to the mixture and mixing operation has begun. 1 minutes of starting mixing, and then cementitious materials have gradually added to the mixture after 5 minutes. After 2 another minutes super lubricants soluble in has been added to remaining water, and mixing operation has been continued for another 2 minutes. Then, samples have been produced using block device.

In addition, in order to treat samples after making them, they have been maintained for 72 hours at 22 ° C and humidity of 55% and in the end have been placed for 24 hours in vitro environment.

Table 11. Mix of natural and artificial lightweight aggregate block

C105	C104	C103	C102	C101	B105	B104	B103	B102	B101	A105	A104	A103	A102	A101	Material Plan code
-	-	-	-	-	-	-	-	-	-	770	750	720	690	670	Scoria (kg / m³) 0-4 and 3-12
-	-	-	-	-	575	550	530	510	503	-	-	-	-	-	Pumice (kg / m³) 3-8
390	370	350	330	300	-	-	-	-	-	-	-	-	-	-	Lika (kg / m³) 0-4 and 3-12
200	250	250	250	300	200	250	250	250	300	200	250	250	250	300	Cement (kg / m³)
24	32	48	70	80	70	60	120	180	160	48	30	100	170	147	Silica sand (kg / m³)
91	120	192	270	310	-	-	-	-	-	-	-	-	-	-	Natural sand (kg / m³)
0.32	0.32	0.32	0.32	0.34	0.33	0.36	0.36	0.36	0.35	0.32	0.33	0.33	0.33	0.34	W/C
64	80	80	80	102	67	92	92	92	105	64	83	83	83	102	Water (kg)
4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	Super Lubricants (Kg)

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Briefly, for every type of lightweight aggregate, 5 series of projects with different ratios as the basic projects to reduce the density, water volume absorption, and to increase compressive strength have been used in the projects follows as Table 11. Other projects have not been mentioned due to the similarity in the mixing ratios to each of these projects.

General trend of implementation of experiments

Lightweight aggregate blocks are classified based on density. so three samples of each of Mix designs for the three types of lightweight aggregates of scoria, pumice and lika, which are in the dimensions of 49 × 15 × 20 cm are soaked in the water for 24 hours with temperature of 16 to 27 ° C to become fully saturated. Weight of immersion mode of samples saturated in water is measured. (Wi) Then they are removed from the water and put on a metal grid with springs at least 9.5 mm for 1 minute until the surface water to be removed from the samples. After that, the visible water is collected by a damp cloth. The sample weight is measured in this state. (Ws) Then the samples are incubated for 24 hours at 100 to 150 ° C to stabilize weight,[1] and to become dried. Their weight is measured after cooling down in the air. (W_d)

The calculation of the density is obtained using the formula (1), and its water absorption is obtained using formula (2) (Standard 70-2) [23]

$$D = \frac{1000W_d}{W_s - W_i} \quad (1)$$

Water absorption (kilometers per cubic absorption) = $\frac{1000(W_s - W_d)}{W_s - W_i}$ (2)

Where in:

D: density in kilograms per cubic meter;

W_d: sample weight after drying in kilograms;

W_s: saturation sample weight in kilograms;

W_i: saturated sample weight in the case of immersion in water in kilograms.

Before implementing experiment of compressive strength, lightweight aggregates blocks samples must be treated in greenhouse for 48 h with a maximum relative humidity of 80% at 16 to 32 ° C. Standard (70-2)

Testing machine that must be cleaned thoroughly with a speed of 0.05 Newton on square centimeter per second must be used to determine the compressive strength of samples. The maximum force on the sample must be noted, and by divide it on the sample surface, compressive strength must be achieved according to Newton on square millimeter (MPa)

3. Investigation of Results

Standard of 7782 for none-load-bearing lightweight aggregates concrete blocks is follow as the Tables (12) and (13) and (14).The measurement results of the blocks' size are ignored in the text. But it is noteworthy that all these measures are compatible with standard conditions.

Table 12. Classification density of cement blocks in accordance with ISO 7782 style

Density category	Density (kg / m³)	Minimum result of each individual sample (kg / m³)	Maximum result of each individual sample (kg / m³)
1	700-500	450	770
2	1000-700	630	1100
3	1700-1000	900	1870
4	2000-1700	1530	2200

[1] Sample dry weight is stabilized when the difference of two successive weighing within two hours is not more than 0.2% of weight

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Table 13. Water absorption of concrete blocks in accordance with ISO 7782-style

The type of blocks based on density category	The maximum volume water absorption (average of three samples) (kg / m³)
1,2,3	288
4	240

Table 14. Compressive strength of non-bearing concrete blocks according to standard style 7782

Minimum compressive strength (MPa)		Compressive strength category
result of each individual sample	Average of three samples' results	
2.0	2.5	CS2
4.0	5.0	CS4
6.0	7.5	CS6
8.0	10.0	CS8
CS = Compressive Strength		

3.1. The results of experiment on lightweight blocks of Scoria

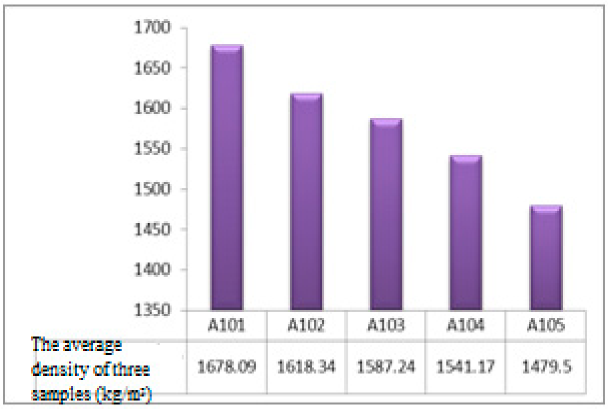

Figure 7. The test results of density (kg / m³)

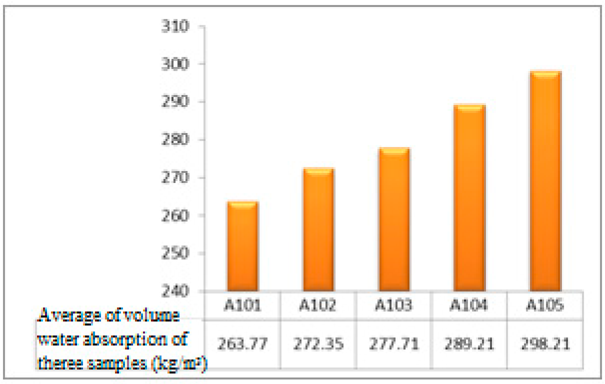

Figure 8. The test results of volume water absorption (kg / m³)

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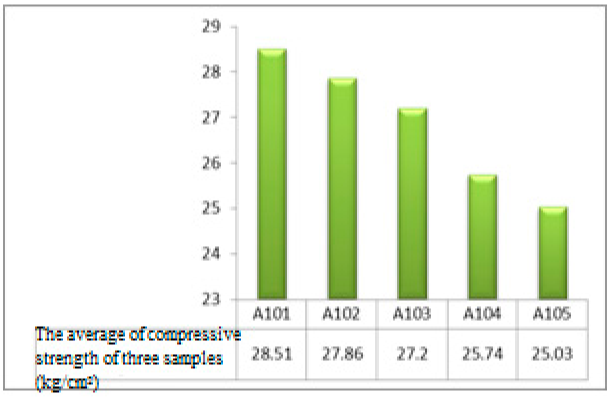

Figure 9. The test results of the compressive strength (kg / cm²)

3.2. The results of experiment on lightweight pumice blocks

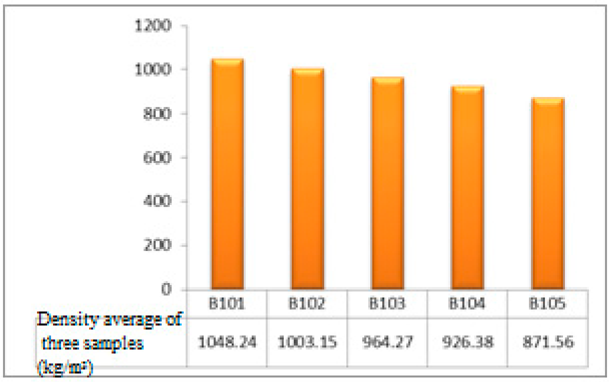

Figure 10. The test results of density (kg / m³)

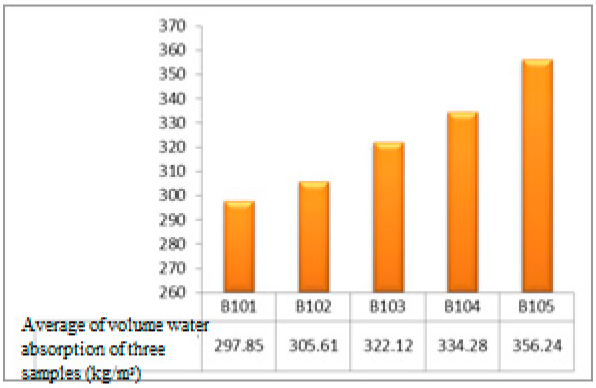

Figure 11. The test results of volume water absorption (kg / m³)

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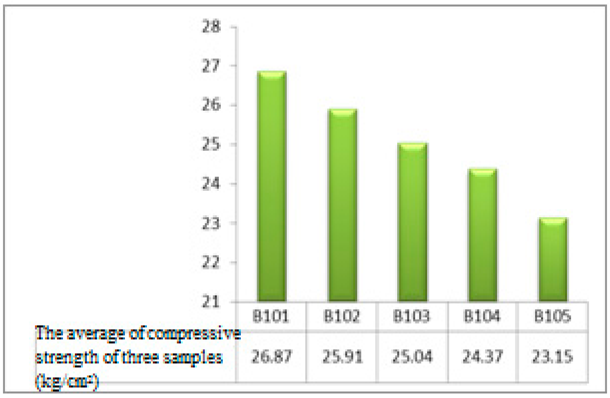

Figure 12. The test results of the compressive strength (kg / cm²)

3.3. The results of experiment on lika lightweight aggregate blocks

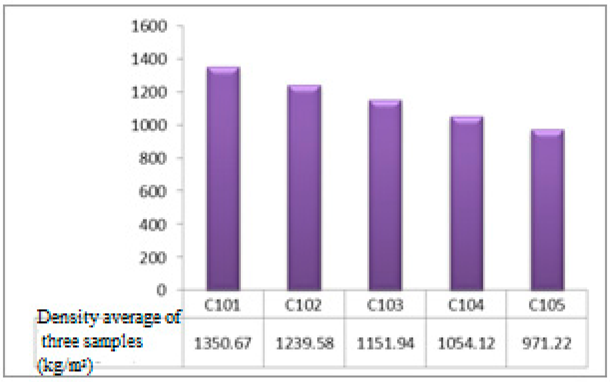

Figure 13. The test results of density (kg / m³)

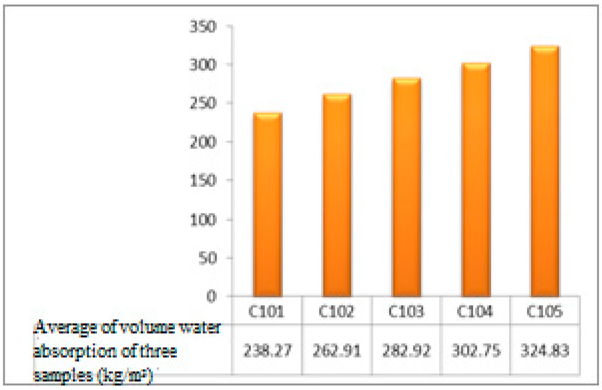

Figure 14. The test results of volume water absorption (kg / m³)

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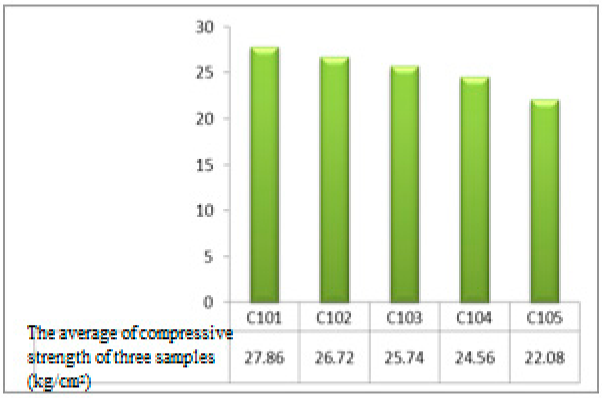

Figure 15. The test results of the compressive strength (kg / cm^2)

3.4. Discussion of Results

Compressive strength of lightweight aggregates concrete is a function of both consuming and mortar lightweight aggregates. So if the mechanical strength of lightweight aggregates to be low, problems of high water absorption of these concretes and erosion during mixing can be reduced by reducing volume of coarse aggregates to total lightweight aggregates, saturating lightweight aggregates before pouring them in the project, using appropriate blenders, using silica sand instead of natural sand as filler.

According to the results of experiments, the most desirable state of mix design for lightweight aggregates block of scoria had been design code of103A, for pumice had been design code of 103B and for lika had been design code of 103C.

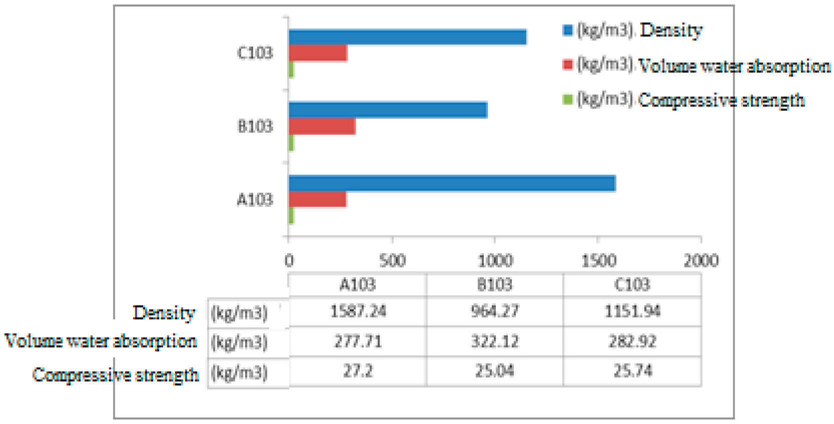

Figure 16. Comparison Chart of compressive strength, density of water absorption volume lightweight aggregate blocks with optimal mix

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Table 14. Ranking density, compressive strength, water absorption volume of lightweight aggregate block in accordance with ISO 7782

Plan code	A103	B103	C103
Density category	3	3	3
volume water absorption	It is less than 288 kilograms per cubic meter. Accordance with the standard.	It is more than 288 kilograms per cubic meter. Does not conform to the standard.	It is less than 288 kilograms per cubic meter. Accordance with the standard.
Resistors category	CS2	CS2	CS2

According to the conducted comparison, lightweight aggregates blocks of scoria due to hard texture and high mechanical strength of its lightweight aggregates; it has had higher compressive strength and lower water absorption volume compared to lightweight aggregates of pumice and lika. Tabriz pumice blocks despite having desirable compressive strength and low density compared to other lightweight aggregates has higher water absorption volume. So it cannot meet standard conditions. This causes it to be less welcome.

Among these, perhaps it can be said lika blocks in term of strength, density and water absorption volume are placed between these two blocks, and have normal conditions.

In addition, although these lightweight aggregates have different mechanical and physical structure and therefore create blocks with different physical characteristics, but it can be implied from the obtained results that regardless to the behavior of lightweight aggregates, block density plays an important role in compressive strength and water absorption volume.

4. Conclusion

The physical properties of concrete are the properties that are true for the entire concrete as a material. Strength is the basic properties of concrete. This property is the basis of designing the structures by designers. In fact, strength is closely related to density. On the other hand, another important item of concrete is its water absorption that is high in the lightweight aggregate concrete due to the high pores of lightweight aggregates.

Within the scope of the conducted studies can be concluded that:

The best cement content in the mix design of lightweight aggregate blocks is 250 and water-cement ratio for scoria is 0.33, for pumice is 0.36, and for Lika is 0.32.

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Density has an inverse relationship with water absorption volume in lightweight aggregate blocks, and has a direct ratio with the compressive strength. Hence scoria block with the highest density (1587.24 Kilograms per cubic meter), the lowest water absorption volume (277.71 Kilograms per cubic meter), and highest compressive strength (2.72 MPa), and Lika blocks is after scoria with density of 1151.94 Kilograms per cubic meter, water absorption volume of 282.92 Kilograms per cubic meter, and compressive strength of 2.57, and then is pumice with density of 964.27 Kilograms per cubic meter, water absorption volume of 322.20 Kilograms per cubic meter, and compressive strength of 2.50.

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