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Research Article

The Effect of Urmia-Lake Water on Mechanical Strength Concrete with Various Admixtures

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Abstract: This study has been investigated the effect of admixtures on the strength of concrete under water with high aggressive ions, for example under Urmia-lake water in West Azerbaijan, Iran. We made different types of concretes with the ratio of w/c and replaced different percentages of micro-silica, air-entraining, super plasticizer, corrosion-inhibiting and caulk with two types of cement I and II as well as investigating in both ordinary water and Urmia-lake water. The strength of pressure, tension, abrasion and freezing and melting was investigated on these samples. The results indicate that admixtures improved strength of concrete under water with high aggressive ions. Finally, the most proper mixture was presented using both types of cement (I and II) and optimal value for micro-silica, caulk and super plasticizer.

Keywords: Admixtures, concrete, strength, Urmia lake

INTRODUCTION

Urmia Lake is the biggest and saltiest lake in Iran. It is the saltiest lake in the world after Bahrolmiyat Lake in Palestine. The necessity of building a bridge, touristic attractions of Melli Park as well as the existence of Artemia in this lake which is economically valuable make it inevitable to build concrete structures. Thus, it seems essential to perform researches in order to find better solutions for building durable concrete in this environment which is full of various ions in general and Chlorine ions in particular (Basheer *et al*., 1996).

The corrosion phenomenon effects on the structures which are made adjacent this water are due to Sulphate ions density, so we can use super sulphated cement to protect reinforced concrete (Bonen and Cohen, 1992; Santhanam *et al*., 2002). Due to the high density of Chlorine ions in Urmia-lake water makes us to use special admixtures. On the other hand, by the use of admixtures we can investigate the effect of admixture in order to improve the concrete specifications in adjacent Urmia-lake water.

General specifications of Urmia-lake water: General specifications of Urmia-lake water in all different seasons and under different geographical conditions are varied and these specifications in high and low tide time are also varied. According to experimental results, specific gravity of Urmia-lake water in 20'c in fall is about 1.59 g/mm and in spring is about 1.146 g/mm. And also, electricity control of Urmia-lake water is about 3*105 and 2.15*105 µmos/cm, pH of this water is between 7.72 and 7.74 and the remainder (dried) after applying temperature about 180'c is between 251 and 235 g/it (Official Reports of West Azarbaijan Environment Office, 2010; Ramazanpur, 1998).

Experimental method and employment of admixtures: To consider the effect of using admixtures material in order to protect concrete adjacent Urmia-lake water as well as the effect of this material on mechanical strength of concrete. We tried to make 15 different types of mixture with 482 concrete cubic and core.

To make these samples, we used Portland cement I and II with different ratio of w/c 0.38, 0.4, 0.44 and also replaced Micro-silica with amount of: 0, 10 and 15%, used weight of cement and made concrete being investigated in Urmia-lake water and ordinary water. Also, the effect of each admixture of Waterproof (W.P), corrosion inhibitor (F.g) and Super Plasticizer (S.P) on pressure, tension, abrasion and freezing and melting on 7, 14 and 28 days concrete samples were investigated.

MATERIALS AND METHODS

This experiment was conducted at Urmia region, North West of Iran, during 2011.

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Micro-Silica (M.S) admixture: In most cases there is a direct relation between the amount of damage and penetrability. Generally the penetrability of concrete is the function of porosity and allotment of apertures measure; here the size of the apertures is more than 0.1 m which affects the amount of penetrability.

Approximately most of the researchers believe in that Micro-silica concrete compared with other ordinary concretes is less penetrability. In the other hand, ordinary concrete penetrability versus Chlorine ions is about 20 times more than the concrete which has Micro-silica (Gjorv, 1993). Researchers shown that adding micro-silica into concrete in all the ages will cause compressive strength of concrete (Koohdaragh and Mohammadi, 2011). From the investigations, it has been revealed that slag concrete of cement slag mix ratio 70:30 has better resistance against strength deterioration for all curing conditions and curing ages. It is primarily due to high fineness of slag, which after hydration markedly reduce the permeability of concrete that restrict the penetration of sea salt (Moinul *et al*., 2010).

Micro-silica is a type of soft material having dimensions about 0.1~0.2 μm (Approximately about centigram dimension of cement). Due to being so fine (soft), Micro-silica granular can fill the apertures of the concrete, it increases the strength and decreases the penetrability as well as increasing the viscosity between the granular of cement and also between cement and grains (Aldred, 1993). Specific mass of this material which contains about 85~98% silica equals 2.2 g/cm^3 and has area about 14 m^2/g (ACI committee 226, 1987).

Admixture of waterproof: The main performance of this admixture of Waterproof (W.P) is to decrease the percentage of absorbing water of harden concrete and permeability of its ratio to the water. Decreasing the number and dimension of small pipes and decreasing the capability of penetrability in order to increase the strength of concrete and its strength versus chemical aggressive is like chlorine ions, sulfate and etc. Also, it makes the concrete get stronger against freezing and corrosion.

Super plasticizer: Super plasticizer is a type of an improved water-reducing admixture. According to code in ASTM-C1017-85, it is a kind of material which causes to make plasticize concrete with a slump more than 19 mm if used in the concrete on protecting its viscosity not separating the grains. This material in code ASTM-C494-85 is called F type and also admixtures which causes to decrease the amount of water and leads to slow-setting cement, is called G type (Akili, 1996).

In using super plasticizer, surface ions active are absorbed by cement grains which cause negative charge in cement grains and make repellent force between them and finally it causes diffuseness in cement grains (Neville and Brooks, 1987). By using super plasticizer material, we can decrease the use of water about 25~35%. As a conclusion, we can make a concrete with a low ratio of w/c and with a high strength (Austin and Robin, 1985).

Air-entraining admixture: By using the cement which has air entraining admixtures in concrete, small air bubbles with the diameter smaller than 20 μm is produced. Bubbles are not connected to each other and here in the mass of concrete scattered steady. In order to have plenty of strength in a concrete which has air entraining admixture against the cycle of frizzing and melting, there exists the characteristics of air entraining in a hardening concrete in the most standards and codes of countries like ASTM-C457. The shape and the thickness of bubbles in stability, especially in its first formation of bubbles in cement are useful.

For instance, if we compare two materials called Cocamidietanolamid and woods resin which is called Rozivenizul it is clear that Cocamid or Dietanolamid (D.E.A) according to the standards of ASTM-C260, ASTM-C233 produce bubbles in concrete which are hard and stable in their shape and structure and distribute steadily and in this case, the concrete got enough strong versus freezing and melting. The air bubbles of Rezinvenizul standpoint of an irregular shape and thin wall in whole concrete doesn't have the same characteristics with the material which is called Cocamid (Klieger, 1985). Concrete with air bubbles has the feature of being stuck and as a conclusion the separation of granular and water loss decrease (Ramazaniyan and Shahhnavazi, 1998).

RESULTS AND DISCUSSION

Investigating the experimental results of pressure strength: Different factors affect the pressure strength of which 3 factors are discussed as follows:

Effect of the ratio between water and cement (w/c) on compressive strength: One of the most important factors to make concrete strong enough versus physical and chemical destructions is the ratio between water and cement w/c. One of the most important roles of water in cement is to create chemical acting like cement hydration. In order to create this action, we use about 0.23 of cement, to protect the effectiveness of concrete we use more than this ratio. In this study, ratios of 0.24, 0.4 and 0.38 are used as an experimental data for cement I and II, the results of this experiment with different environmental conditions (ordinary water and Urmia-lake water) are shown as a linear graph in Fig. 1 and 2. Here we can see that as we decrease the ratio between the water and cement (w/c), considerably we can increase compressive strength. In all samples if their lives increase, compressive strength increases and

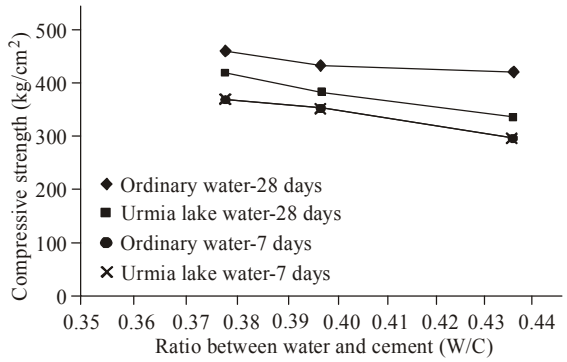

Fig. 1: Compressive strength for different ratio between water and cement in condition of ordinary water and cement I

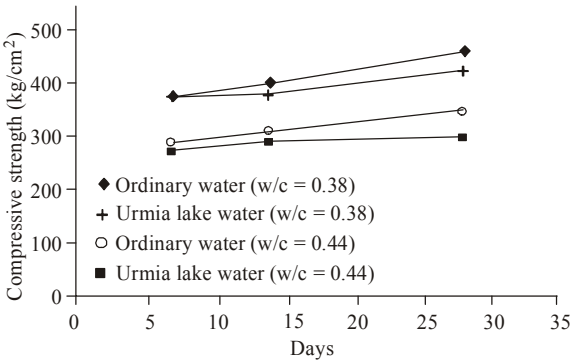

Fig. 2: Compressive strength for area condition and different ratio between water and cement, cement II

here in these samples which are made of cement we have more percentage of C3A, C3S than cement II, so compressive strength is high. It leads to decreasing 5% of C3S and 6% of C3A in cement II. This material causes time of hardening to increase on the first days of concreting.

In decreasing the ratio between water and cement (w/c) causes no decrease compressive strength of concrete as made in Urmia-lake water, it is because of decreasing porosity and control aggressiving. By the passing of time, the increase in time of hardening of samples in Urmia-lake water makes more difference in compressive strength than those made of ordinary water; it is because of continual diffusion of magnesia sulfate and sodium sulfate.

The effect of in replacement percentage of micro-silica on compressive strength: Micro-silica of extraordinary Pozzolanic activity causes hydroxide Calcium transit to Silicate Calcium hydrated and increase gel in cement paste. Similarly, due to very soft and fine grains about 0.1 to 0.2 μm they fill the gap between gel and cement grains, finally as a result by decreasing porosity and permeability which increases the compressive strength (Scrivener *et al.*, 1998; Papadakis, 1999; Bhanja and Sengupta, 2003).

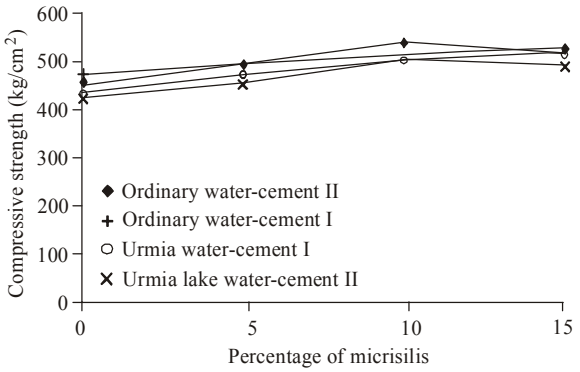

Fig. 3: Twenty eight days of compressive strength for area condition and different cement

The effect of substituting Micro-silica in mixes causes to increase compressive strength compared with a similar concrete without Micro-silica. As it is clear in Fig. 3, compressive strength of samples which are made of cement I increases by increasing the percentage of subsuming of micro-silica, if it is for mixes made by cement II does not match with this rule about a 15% of micro-silica and its compressive strength is less than the compressive strength of samples made by 10% of micro-silica. It is because of the first mechanism of Micro-silica and built blocks of cement II (C3A, C3S).

In this mechanism the main function of micro-silica is to combine with unstable hydroxide calcium and make it stable and resistant it micro-silica, hence decreasing hydroxide calcium and paying attention to chemical function we will need less amount of Micro-silica. Because, if we use micro-silica more than it's needed, it increases the volume, decreases its viscosity as well as it compressive strength.

The effect of waterproof admixture and corrosion-inhibiting on compressive strength: To protect bars in concrete vs. corrosion, especially the corrosion which it was caused by aggression of chlorine ions from admixture of anticorrosion, waterproof admixture is also used to block water and decrease concrete penetrability against water and aggression of sulfate ions mostly found in Urmia-lake water.

Through investigation of these samples and the concretes made of ordinary water and lakes water, it is assumed that by adding admixtures like waterproof and anticorrosion to the mixture which has about 10% of micro-silica cause to decrease compressive strength of concrete.

If we make our samples by Urmia-lake water it shows that the samples which are made of anticorrosion compared to the ones made of waterproof decrease more (Fig. 4). To decrease the permeability of concrete by waterproof is one of the better reasons of its behavior in Urmia-lake water.

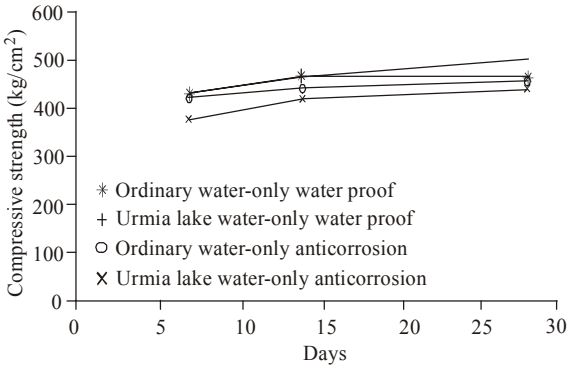

Fig. 4: The effect of waterproof and anticorrosion on compressive strength of concrete in ordinary water and Urmia-lake condition

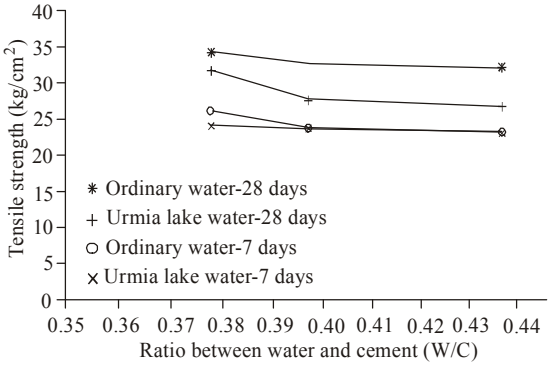

Fig. 5: Tensile strength for area condition mindfully different ratio between water and cement and cement I

Investigating the experimental results of tensile strength:

The effect of the ratio between water and cement: Decreasing the ratio between water and cement for making concrete leads to the decrease of void and porosity and increases its durability and strength, as we considered before the same result in last part for compressive strength and here it is spoused by decreasing the ratio between water and cement and we reach the same result for tensile strength. In all concrete samples without paying attention to conditions and type of cement, increasing the life time of concrete tensile strengthen its tensile.

If we pay attention to graphics, it is clear in two important points that, first: decreasing the ratio between water and cement in samples will decrease the tensile strength for the samples which are made in Urmia-lake water, it is because of decreasing porosity and controlling the diffusion of chlorine, sulfate attack and ... which are caused by decreasing the ratio between water and cement.

Second, as time passes and the time of embedment of the samples in Urmia-lake water makes more difference in tensile strength like the ounces made in

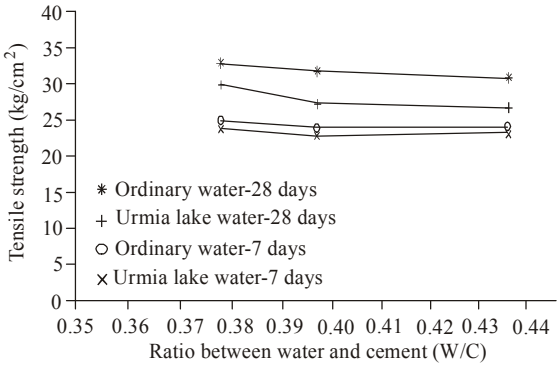

Fig. 6: Tensile strength for area condition mindfully different ratio between water and cement and cement II

ordinary water and this is due to continuous attack of diffusion.

The most important point that we pay to attention more in Fig. 5 and 6 is that tensile strength of samples made by cement I and the same type made by cement II makes no difference. Whereas compressive strength of the samples which are made of cement I have more compressive strength than the samples which are made of cement II.

The first reason is that the samples made by cement I are brittle and this is due to high percentage of C3A and C3S in this cement and this leads to the flash setting of concrete. The second reason is decreasing the ratio of the tensile strength to compressive strength in hard concretes.

The effect of substitution percentage of micro-silica on tensile strength: Tensile strength (Brazilian experiment) of concretes having Micro-silica increases with different percentages of substitution without paying attention to the type of the cement used. Whereas, substituting 15% of Micro-silica increases tensile strength of in ordinary condition about 22% to the witness sample (without micro-silica). This quantity for the samples made of cement I or II which are made by Urmia-lake water is about 20%. Increasing the tensile strength on concretes which have Micro-silica similar to their compressive strength is because of two important micro-silica mechanisms, namely, the property of its Pozzolanic and so fine grains. In this paper, it is considerable that study on the effect of Urmia-lake water on tensile strength of concretes shows in all cases Urmia-lake water cause to decrease the tensile strength of concrete (Fig. 7).

The most important point of the tensile breaking samples which have Micro-silica, is their brittle and sudden break. We can increase the brittle and sudden break of the samples by increasing the percentage of Micro-silica. In tensile breaking samples without micro-silica is mostly accompanied with crack and sometimes like rift. Whereas in the samples with

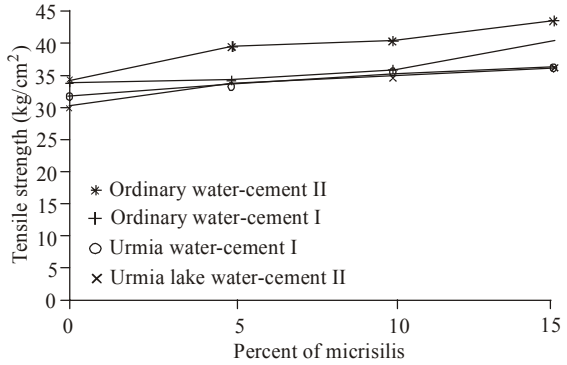

Fig. 7: Tensile strength of 28 days of samples with different percentage of micro-silica for different condition of areas and different cement

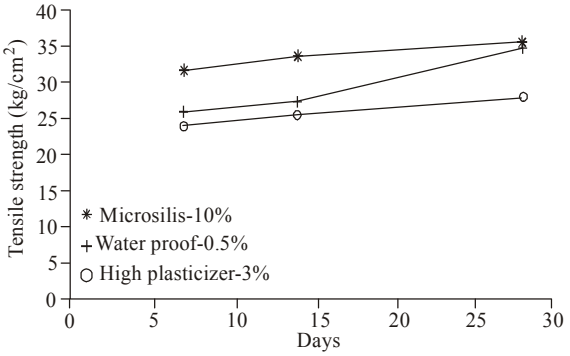

Fig. 8: The effect of waterproof and anticorrosion admixture on tensile strength of concrete in Urmia-lake water condition

Micro-silica cause the samples to be open and made half. This action for the samples with more micro-silica, make in faster and sudden and with an explosion noise.

The effect of admixture studied on tensile strength: The results of investigation and the effect of each admixture waterproof, anticorrosion and entraining agent are shown in Fig. 8.

Study the graph shows that if we added more waterproof than needed and anticorrosion to the samples which have about 10% of Micro-silica cause to decrease tensile strength but this decreases about 18% for the samples which are made by ordinary condition with waterproof. Also this quantity for the samples made in Urmia-lake water is about 1.3 and 20% and as shown in samples with waterproof decrease the tensile strength versus aggressing (chlorine, sulfate, ...) in Urmia-lake water. The first mechanism of micro-silica in these two combinations (combination like waterproof and anticorrosion) are the main reasons which decrease the tensile strength.

In order to study the effect of air entraining on tensile strength we have presented (Fig. 9). As it shows, adding admixture of air entraining decreases the tensile strength of concrete to witness concrete. It is justifiable

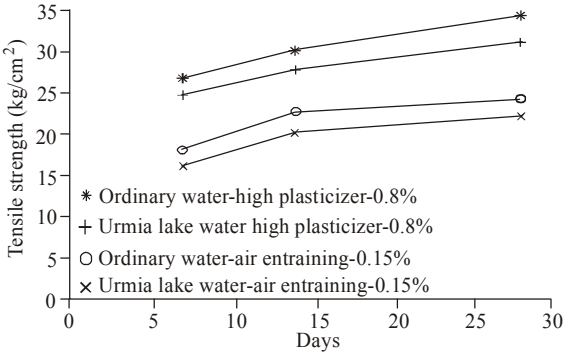

Fig. 9: Comparing the compressive strength of concrete which has air-entraining with the concrete has high plasticizer in different area water condition

that adding this type of admixture increases the air-entrained and porosity in concrete.

Investigating the experimental results of wearing resistance according to ASTM-C779 standard: This experimental investigation of wearing resistance combination is one of the important points which show that the movement of the seas causes a type of phenomenon called abrasion. As it is clear, the velocity movement of the Urmia-lake is so slow (about 0.5 m/s), therefore it is possible to make cavitations with an approximate velocity about 12 m/s, therefore it is so weak and probability cannot make cavitations. But because of its continuity of hitting to the structure made in sea we decided to study about wearing resistance of concrete and its combination. Mindfully, increasing compressive strength causes wearing resistance to increase, so compressive strength is one of the most important factors of its wearing resistance.

The effect of the water and cement ratio on wearing resistance: In order to study about the effect of the ratio between the water and cement on wearing resistance, Fig. 9 had been made. If we study more about the Fig. 9, we can conclude that decreasing the ratio between water and cement increases wearing resistance like compressive strength of concrete.

Also the samples which are made in Urmia-lake water got more abrasion compared to the ones made in ordinary water and it is because of influence of aggression in lakes water. Consider Fig. 10. In order to compare wearing resistance for the samples which are made of two different types of cement I and II with the same condition and ratio between water and cement, we can concluded that like compressive strength, wearing resistance of the samples made by cement I is more than the samples made of cement II in same condition. Increasing the ratio between the water and cement the last results will be changed more and at least cement I will be more preferable than cement II.

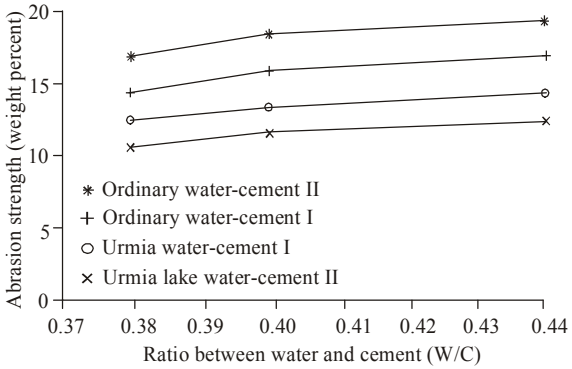

Fig. 10: Comparing the abrasion of samples made with different ratio of water and cement and species cement

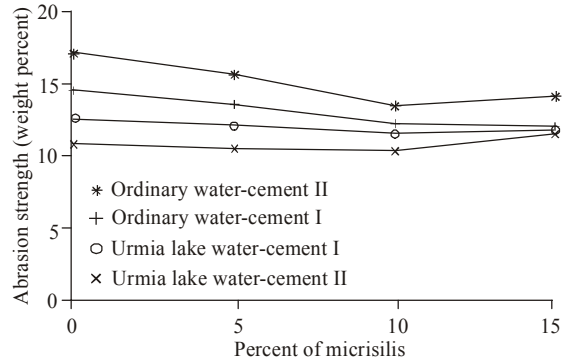

Fig. 11: Comparing the amount of abrasion for different percentage of substituting of micro-silica

The effect of substituting percentage of micro-silica: To show the effect of substituting Micro-silica on wearing resistance and the results of the experimental samples which have Micro-silica we present Fig. 11. By studying this graph, we can conclude that substituting Micro-silica in every combination without paying attention to the type of the cement and the situation they made cause to decrease the abrasion. First, this is because of the activity of Pozzolanic of micro-silica, so it produces more gel in cement paste. Second is because of its fine grains which act as a backfill between gels and cement grains. Another point we should pay attention to on this graph is increasing the percentage of substituting of Micro-silica in cement I (ordinary cement) which increases wearing resistance of concrete. Whereas for the samples made of cement II (modified) increasing the percentage of substituting of Micro-silica up to 10% cause to increase and more than that cause to decrease wearing resistance.

Performing the samples in Urmia-lake water (without paying attention to the type of cement) decreases wearing resistance of samples.

The effect of admixtures on wearing resistance: If we investigate Fig. 12 which is made for studying about admixtures (waterproof, anti corrosion, air-entraining)

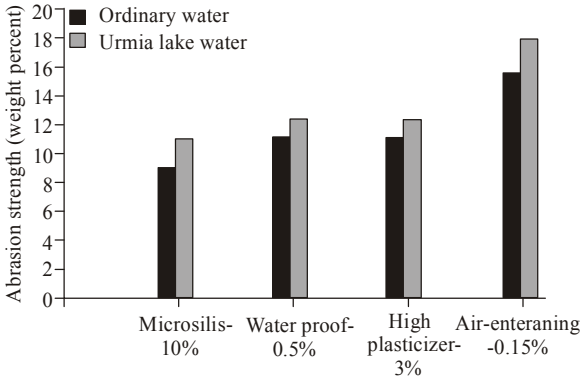

Fig. 12: The effect of admixtures on amount of abrasion

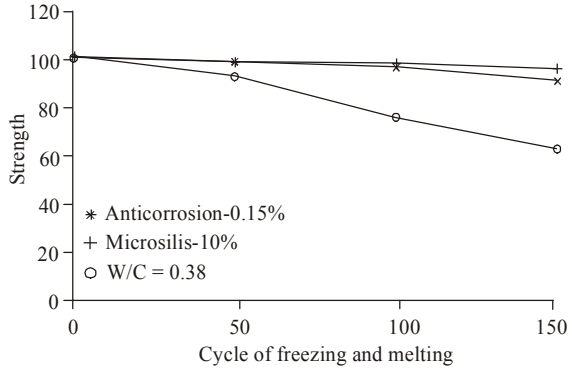

Fig. 13: Weatherproof of freezing and melting in ordinary water area condition

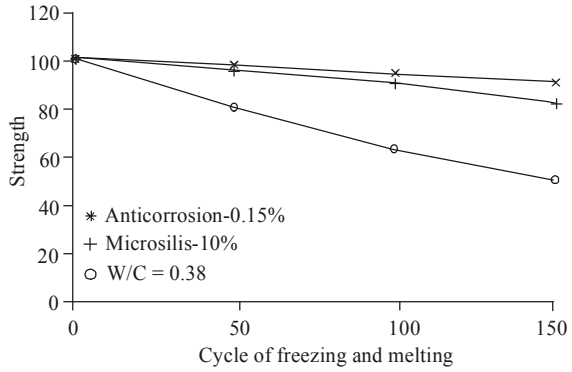

Fig. 14: Weatherproof of freezing and melting in Urmia-lake water area condition

on wearing resistance of concrete, we can conclude that like compressive strength; adding admixtures above decreases wearing resistance of concrete. However, this decrease for the samples which have waterproof is approximately less than two other types of admixtures. Also, because of decreasing permeability of samples which have waterproofed, the difference between their wearing resistances with witness samples (10% of Micro-silica) that both made in same condition is less than two other admixtures.

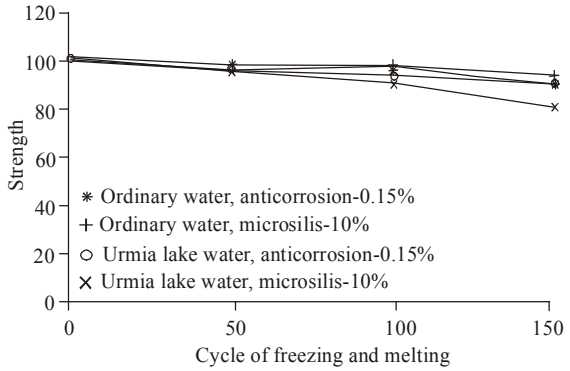

Fig. 15: Comparing the samples resist in freezing and melting in ordinary water with the samples in Urmia-lake

As it is shown in Fig. 12, it is completely considerable that the samples with air-entraining admixture got less wearing resistance by then increasing porosity and decreasing compressive strength are the main reasons of decreasing wearing resistance in these samples.

To experiment the strength versus the cycle of freezing and melting with ASTM-C66 standard: Reading the fact that Urmia-lake located in equable mountainous data given by meteorological office and reported the weather of lake and its island in the coldest month is about 22c', so it is possible to freeze the water scattered on structure (Fig. 13, 14 and 15). Therefore, to protect the destruction of concrete located in this area, the samples are experimented in the same situation (freezing and melting).

CONCLUSION

- Decreasing the ratio between water and cement here in this study which is the most useful ratio of about 0.38 increases concrete resistance.
- The results show that the concrete made by cement I is stronger than the one made by cement II.
- Substituting 10% of Micro-silica in the samples made by cement I and II is known as an ideal percentage in this study.
- Waterproof admixture decreases the amount of diffusion of chlorine ion and increases electrical strength of samples.
- Using anticorrosion admixture, with 10% of substituting Micro-silica causes to decrease the strength and increases the permeability.
- Using air-entraining admixture decreases the compressive strength of concrete.
- Generally considering all the results and outcomes reveals that the combination accompanied by cement I and 10% of micro-silica as well as 0.5% of waterproof tend to be economical and endurable.

RECOMMENDATIONS

- Determining the well mix design with environmental condition (high compressive strength and low permeability)
- Using cathodes protection and studying about their type and amount and studying about other appropriate covers
- The long-term effect of Urmia-Lake water of mechanical features of concrete
- The investigation of the water ratio to cement in wide researches to obtain makes general results

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