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Research Article

Investigation of the Effect of Larestan's Pipeline Water on the Mechanical Properties of Concretes Containing Granite Aggregates

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In this study, the compressive strength of the concretes made by the pipeline water of Larestan has been investigated. Although the used water for the concretes must be clean, standard, and generally drinkable water, in Larestan city, the pipeline water is nonpotable water; meanwhile, this type of water is still being used in the mixture of the concretes by companies and contractors. Since in the initial tests the compressive strength of the normal samples did not satisfy the standards, 50% of granite aggregate was replaced with the purpose of increasing strength of the samples. Then four types of samples were made, which are (1) normal concrete with pipeline water, (2) normal concrete with potable water, (3) granite concrete with pipeline water, and (4) granite concrete with potable water. The results showed that the compressive strength of normal samples is not standard in the case of using the pipeline water. This issue can be seen during the first four weeks of the samples, whereas these samples are placed in the standard zone by replacing 50% of granite aggregate instead of normal aggregates. This may be attributed to the compensating effect of granite aggregates in opposition to damaging effect of water. Also, by using the granite aggregates in the mixture, the compressive strengths of the samples were standard and almost identical in both cases of pipeline water and tap water. As a result, the concretes made in this city must include additives for increasing the strength, or the tap water should be used as a replacement for pipeline water.

1. Introduction

The use of concrete in construction has widened recently. Concrete is a good material in the pressure situations, and thus it can have high performance as a column in structures. The compressive strength is the primary parameter in design, implementation, and quality control of the concretes. Moreover, compressive strength is the most useful parameter in the national and international agencies and other parameters such as modulus of elasticity, tensile strength, and compressive strain are expressed as a function of compressive strength [1]. There are many important factors that can affect the specifications of the concrete and its strength, such as the degree of consolidation [2], water-to-cement ratio [3], moisture [4], cement hydration [5], replacements [6], and type and size of aggregates [7, 8]. Also, water is one of the parameters that can affect the specification of concrete. Usually, water represents about one-third of the whole concrete mixture and its direct influence is on the water-cement ratio. But another aspect of water influence is the content of water. American Concrete Institute (ACI) suggests that any drinkable water is suitable for use in the concrete. Currently, the use of some types of water like seawater is prohibited because of the high content of chloride as the chloride of water intensifies the corrosion of reinforcing [9]. The concrete industries consume about one billion cubic meters of water annually. This volume of water is just for mixing, so the enormous amount that must be added is used for washing the mixer, equipment, and pumps, as well as curing the concrete [10]. Studies of prediction showed that, until 2025, the 75% of water demand for concrete use will be in areas that have water reduction [11].

As a result, the investigation for replacement of other sources of water such as seawater [9], wastewater [10], underground water [12], and recycled water [13] has started. Some experimental work on compressive strength of concrete with 100% replacement of treated wastewater instead of tap water has been done. The two types of samples had the same curing process. The result showed that the compressive strength of samples with treated-water replacement is about 85–94% of normal concrete [14]. An investigation on the use of treated grey water (TGW) and raw grey water (RGW) showed an increased rate in the initial setting time and a decrease in the slump. Also, an increase in the compressive strength of TGW samples was seen but, in RGW samples, the compressive strength decreased [10]. The application of seawater, tap water, and salt water in the concrete has been investigated. The compressive strength of the samples was tested after 20 years. The seawater samples had earlier strength gain but they didn't show different compressive strength after a long time [15]. On the other hand, in some investigations, the compressive strength of concrete samples decreased due to the use of seawater. In this study, the difference between the compressive strength of tap water samples and that of seawater samples was less but, after 12 months, the difference got larger and reached 10 MPa in some cases [16]. Also, an investigation on the use of magnetic field treated water (MFTW) showed a better compressive strength of concrete compared to tap water concrete and it had a better strength at an early stage [17]. This early strength could happen because of the interaction between magnetic water and cement hydration. However, tap water in some countries or some areas of a country is very scarce. So finding a replacement for tap water in these areas is important and this new type of water should satisfy the criteria of standards.

Larestan is a city in the south of Iran. It is located in Fars province and is about 370 km from Shiraz and 220 km from Bandar Abbas (Figure 1). The prevailing climate there is hot and dry. So the water resources are very scarce in this area. In the past, the people used underground water or rainwater gathered in a kind of source called "Berkeh." Nowadays, with the development of cities, they became unusable and have been replaced by plumbing. But plumbing water in this city is not drinkable and the people must get the tap water from other sources or by using water desalination machine. Since getting tap water is not easy in the work zones, the contractors use plumbing water in their construction processes such as making concretes, mortars, curing, and so forth.

The aim of this study is to investigate the properties of concretes that have been made by the plumbing water of this city. Although the plumbing water of this city is not drinkable, no one has investigated the effect of that type of water on the concrete structures. Since the water has a salty taste, it is probable that the water contains chloride ions. The presence of chloride is one of the main reasons for reinforcement corrosion and many other problems in the concrete [19] and also has an effect on the cement paste by raising Friedel's salt creation, increasing the $Ca(OH)^2$ content, and retarding the diffusion of chloride ion [20, 21]. However, Shi et al. [22] investigated the effect of seawater on the mechanical properties, mineralogy, and microstructure of alkali-activated materials (AAMs) and showed that seawater is suitable for use as mixing water of the AAMs in the marine environment. Nevertheless, until now, no investigations were conducted on the effect of water on the concretes and steel bars which are made in this region.

2. Materials and Methods

As mentioned, there are many solutions to improve concrete performance. Some alternatives are improvement or replacement of aggregate, changing of mix design, or using additives. Based on Iran's concrete standard, the quality of the materials must satisfy certain criteria to prevent any damage to the structures. So, in tropical zones where the possibility of corrosion is higher, the use of more covers for reinforcement and making concrete with low porosity are inevitable [23]. The materials below have been used in this study to create concrete samples; further information on them is given in the following.

2.1. Cement. Cement is the most consumed material around the world, of which people use four billion tons annually. This is about 560 kg for every person [24]. Generally, the increase of cement in the concrete and consequently decrease of w/c ratio in the mix will produce stronger concrete [3, 25, 26]. Also, the quality of the concrete is important in compressive strength of the samples. The use of organic cement instead of normal Portland cement has been investigated. The compressive strength of organic samples was about 1/3 of normal samples. But this ratio was 1/2 in the tensile test [27]. The used cement in this study is type II Portland cement that is provided from Bandar Abbas. Since Larestan's cement factory produces white cement and there isn't any Portland cement factory in this area, almost all of the required cement of the region is provided from there. The physical and chemical properties (XRF analysis) of the cement can be seen in Tables 1 and 2 respectively.

2.2. Aggregates. Sand, gravel, and crushed stone that have been known as natural aggregates form the most part of the concrete mix in both aspects of volume and mass. For any concrete construction, many mined aggregates are needed. Investigation on the aggregates consumption showed that more than 40 billion tons are consumed annually. From this huge amount, between 67% and 75% belongs to concrete making [28]. According to the standard, the used aggregate must be clean and durable and must have no harmful chemicals [29]. In some studies, the replacement of aggregate was mentioned as a good condition and in some cases the properties decreased. This can be referred to the origin of aggregates and their strength. But it is clear that the specifications of the aggregate such as shape, angularity, strength, and durability can affect the compressive strength of concretes. The effect of using marble as a replacement for natural coarse aggregate in concrete has been investigated. The natural aggregate was replaced by marble aggregate in the weight percentage of 0–100%. The results showed 14% better

Figure 1: Location of the case study. Larestan is a city in the south part of Iran and is the largest city in Fars province [18].

Table 1: The physical properties of used cement: the most commonly available cement in Larestan (Hormozgan type II Portland cement).

Title	Unit	Test	Min	Max
Fineness	cm^2/g	Blain test	2900	3200
Expansion	%	Autoclave	0.05	0.16
Setting time	Minute	Initial	120	160
		Final	170	310
			200	250
Compressive strength	After 3 days	kg/cm^2	270	320
			350	420

Table 2: XRF analysis of used cement.

Chemical composition		Content (%)
Silicon dioxide	SiO_2	21.25
Aluminium oxide	Al_2O_3	4.95
Ferric oxide	Fe_2O_3	3.75
Calcium oxide	CaO	64.00
Magnesium oxide	MgO	1.50
Sulphur trioxide	SO_3	2.00
Potassium oxide	K_2O	0.60
Sodium oxide	Na_2O	0.40
Loss on ignition	L.O.I	1.75
Insoluble residue	I.R.	0.40
Free lime	Free CaO	1.05
Lime saturation factor	LSF	94.50
Silica module	SiM	2.50
Alomina module	AlM	1.30
Tricalcium silicate	C_3S	55.00
Dicalcium silicate	C_2S	20.00
Tricalcium aluminate	C_3A	6.50
Tetracalcium alumino ferrite	C_4AF	11.0

workability for marble aggregate samples and an increase of 40% and 18% in the compressive strength at 7 days and 28 days, respectively [30]. Figure 2 shows the used aggregates in this study, which were crushed aggregates and aggregates from local mines in Larestan (Figures 2(a) and 2(b)). Both fine aggregate and coarse aggregate were mixed with 50% of granite aggregate in the second type of concrete samples (Figure 2(c)). The reason for avoiding full replacement is the high cost of granite aggregate. Granite is one of the powerful aggregates that can be used in making concrete to increase the strength. Investigation on the use of granite aggregate as replacement for fine aggregate showed a 22% increase in the compressive strength [31]. Also, positive effects on the mechanical properties of concrete were seen in some studies

(a) (b) (c)

Figure 2: The used aggregates in the concrete samples. (a) Natural coarse aggregates. (b) Granite coarse aggregates. (c) The granite fine aggregates.

with the replacement of granite [32]. Also, the gradation curves for aggregates have been shown in Figures 3(a) and 3(b) for fine aggregates and coarse aggregates, respectively. The black-dashed lines are the margins of limitations between which the curves are located and they show the acceptable gradation of aggregates for concrete mixing.

2.3. Water. The used water must be clean and must have no chemical content, and, generally, tap water from any source is suitable for making concrete. Any other types of water may have some effects on the properties of concrete or corrosion of the reinforcement [23]. As an example, the use of salty water like seawater is not permitted because after using it in making concrete it can cause some problems such as corrosion, swelling, and fracture [33]. Investigations on the use of magnetized water in making concrete showed that, in comparison to normal concrete, it has the same or even better compressive strength, while it decreases the required cement [34]. Regarding the country's vast territory, large variety of water quality is expected and it is possible that in some areas the quality does not meet the standards. So it seems necessary to investigate this issue. As a result, providing good quality of water for making and curing of concrete is inevitable.

One of these probable areas that are expected to not have a good quality of water is Larestan in the south part of Iran. The chemical properties of water in Larestan are shown in Table 3. This table is based on the monthly field measurements of the pipeline water characteristics of the city in different stations which have been reported by the local water administration. Also, for better comparison, the quantity of each indicator for drinking water of Tehran is shown as well. The water in Tehran is drinkable and it is known as standard water for making concrete in Iran. These parameters were compared to acceptable limits in the Iranian Water Standard Book No. 1053 and the status was shown in the table. The acceptable limit consists of properties such as physical, chemical, and biological properties as well as radioactivity of the drinkable water.

Considering the above table, some noticeable point can be discussed. The water degree of hardness is very high and it is classified as very hard water based on the content of $CaCO_3$ in the classification of WQA (Water Quality Association) for water hardness [37] (Table 4). The temperature of the concrete mix is one of the most important parameters in the design steps, especially in the hot areas where the rate of water loss is higher. As can be seen, the temperature of Larestan's water is higher than the acceptable limits, so the vaporization of water must be included in addition to the previous parameters.

3. Experimental Method

In this study, four different types of mixture have been used. The first one is the samples made with plumbing water of the city and the second type is the samples made with drinkable water (or tap water). Moreover, the granite aggregates are used in these two categories to support concrete samples against the probability of weakness due to the effect of salty water. Normal water was used in the curing procedure for all the samples. As a result, four groups of samples were created and, by following the same curing procedure for all samples, the variable parameters can be seen from the compressive strength of normal samples and granite samples (Table 5). The drinkable water that was used had been got in the lab from the "water desalination system" that can be seen in Figure 4. This system works with the reverse osmosis procedure and the output is tap water. The ACI absolute volume method has been chosen for concrete mixture design and the slump of the mixture was taken at 6 cm. Also, the water-to-cement ratio has been considered as 0.45 and the maximum aggregate size has been limited to 19 mm. The materials were mixed in the manual concrete mixture at the lab and then they were poured into the molds. The molds should be clean and clear of any physical or chemical wastes so they were cleaned and dried before use. The plastic molds were used in this study because they have no corrosion or sticking probability in making concrete (Figure 5). The molds are cubical with the dimensions of $15 \times 15 \times 15$ cm. Each mold was filled in three stages and each stage was consolidated by the minimum 10 tamping rod to avoid honeycombing concrete. Four different types of concrete were made in this study. The first one is the samples with the normal aggregates where the tap water was used. The second one has the same design and the type of water used is the pipeline water. The

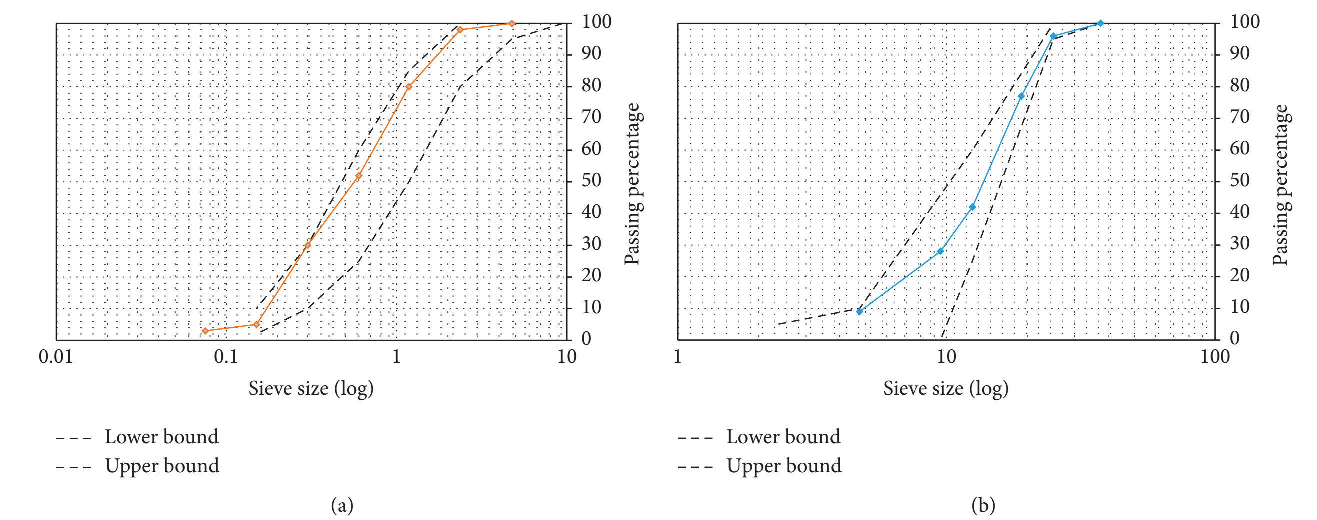

FIGURE 3: Gradation curves of the aggregates with the upper and lower standard limitations. (a) Fine aggregates. (b) Coarse aggregates.

TABLE 3: Comparison of drinking water of Larestan and Tehran with the Iranian Water Standard. The unspecified parameters are shown by dashed cells [35, 36].

Type	Content in Tehran water	Content in Larestan water	Max. acceptable limit	Status for Larestan water
PH	7.7	7.92	6.5–8.5	Acceptable
TDS	—	670	1000	Acceptable
Chloride (Cl)	142	208	250	Acceptable
Sodium (Na)	—	132.1	200	Acceptable
Calcium (Cal)	88	93.6	300	Acceptable
Free residual chlorine (g/L)	—	1.5	0.5–1	Unacceptable
The degree of hardness ($CaCO_{3)}$	284	410.4	200	Unacceptable
EC	423	1453	400	Unacceptable
SO_4	70	264	250	Unacceptable
Mg	20	43.74	30	Unacceptable
Turbidity (NTU)	—	1.15	Less than 1	Unacceptable
Temperature (C)	—	26.1	10–20	Unacceptable

TABLE 4: The degree of water hardness based on the American Society of Agricultural and Biological Engineering (No. S-339) [38].

Degree of hardness	ppm (mg/L)
Soft	<17.0
Slightly hard	17.1–60
Moderately hard	60–120
Hard	120–180
Very hard	>180

TABLE 5: Concrete mix design for the normal samples and samples with 50% granite replacement.

Item	Normal concrete	Granite concrete
Cement	425	425
Coarse aggregate	942	471
Fine aggregate	821	410.5
Coarse granite aggregate	—	471
Fine granite aggregate	—	410.5
W/C ratio	0.45	0.45
Slump	60 mm	60 mm
Air voids	2%	2%

two other types of concrete were created by replacing 50% of aggregates by granite aggregate. Because there are 5 timing stages for breaking the samples, a total of 60 concrete samples were made in the laboratory.

All samples were left in their mold for 24 hours to achieve the initial set of concrete. Then the samples were named separately, moved to the curing place, and kept there until the time of the test (Figure 6). The curing conditions are as follows:

(i) Samples are completely soaked in water (Figure 7)

(ii) The samples were rotated for the same curing conditions for all sides of the samples

(iii) The water temperature is kept at 30°C

(iv) The type of water used for the curing procedure is tap water

Since there are two different types of concrete samples, the curing system and condition were the same for both of them. The temperature of the water is controlled with the digital thermometer. For better analysis and less error in the test, 3 samples of each type of concrete were made and

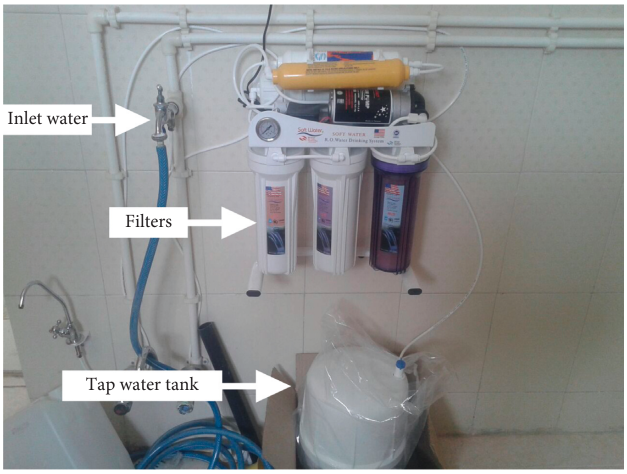

Figure 4: The water desalination system which gives the tap water output. It is working by the reverse osmosis procedure.

Figure 5: The used plastic. The plastic was chosen for better quality of samples and to avoid sticking.

Figure 6: One of the normal concrete samples (without granite aggregates) after 24 hours of curing in water.

Figure 7: The soaked samples which are controlled by the digital temperature controller at 30°C for the first 24 hours.

their average was used as the output. The test plan for breaking the samples was after 7, 14, 28, 56, and 90 days. The compressive strength test was based on the ASTM C39–86 and with the automatic hydraulic jack. Based on the concrete standards, the compressive strength of any concrete which is made using any type of water other than tap water must be at least 90% of the strength in the normal concrete. So this study has investigated the effect of Larestan's water on the short-term and long-term performance of concretes.

4. Results

Based on the previous plan for breaking the samples, they were broken on days 7, 14, 28, 56, and 90. For each test, three samples were used and the average strength was reported. The variance of outputs was acceptable for all samples because no dispersion larger than 4 MPa (±2 MPa) was seen in the results. Also, the samples were checked after the test for the probability of honeycombing concrete or any other problems, but no defect was seen in any of them. The main compressive strength that is presented in the tables and figures is the average measure of them.

The output data of breaking the samples for both tap water and pipeline water used in concrete based on the age of the samples are presented in Tables 6 and 7 and Figures 8 and 9, respectively.

Based on the figures, it can be seen that the highest compressive strength in the samples with the normal aggregate was 36.4 MPa on the 90th day and it has decreased to 33.2 MPa by using the pipeline water. Also, for the concretes with 50% of granite aggregate, the highest achieved strength was 48.5 MPa and it decreased to 48.2 MPa on the 90th day. The higher strength values of granite concrete in both sections are probably due to the effect of granite on the compressive strength. Moreover, granite concrete samples

Table 6: The results of the compressive strength test of normal concrete samples made by using tap water and pipeline water.

Age (day)	Tap water concrete (MPa)	Pipeline water concrete (MPa)	Strength decline (%)
7	17.4	14.8	14.9425
14	23.9	20.9	12.5523
28	29.4	26.2	10.8843
56	30.3	27.4	9.57095
90	36.4	33.2	8.79120

Table 7: The results of the compressive strength test of concrete made by using tap water and pipeline water with 50% of granite aggregate.

Age (day)	Tap water concrete (MPa)	Pipeline water concrete (MPa)	Strength decline (%)
7	20.4	19.1	6.3725
14	26.2	24.8	5.3435
28	35.4	34.5	2.5423
56	42.1	41.5	1.4251
90	48.5	48.2	0.6185

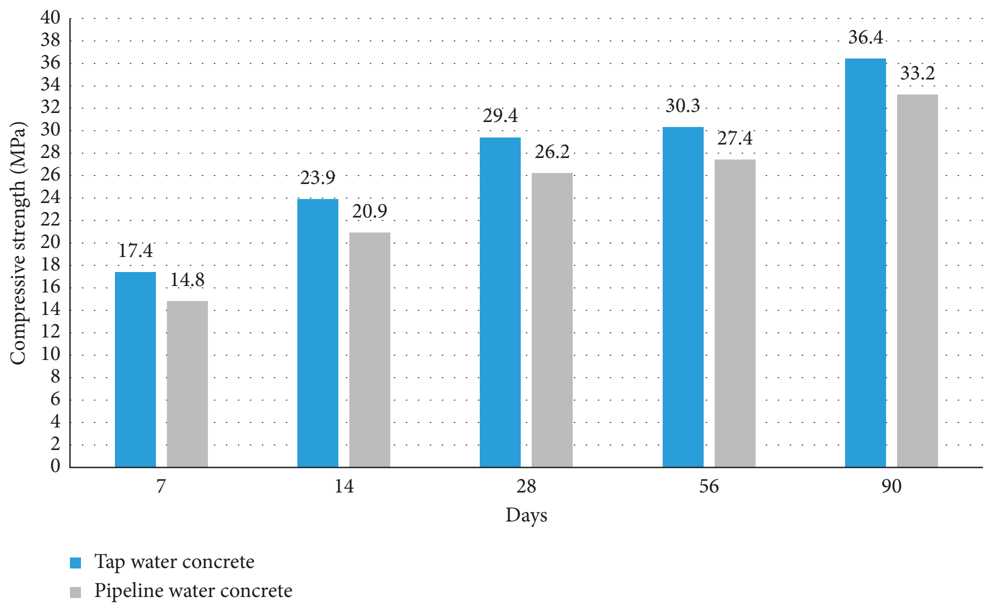

Figure 8: Comparison of compressive strength in tap water concrete and pipeline water concrete.

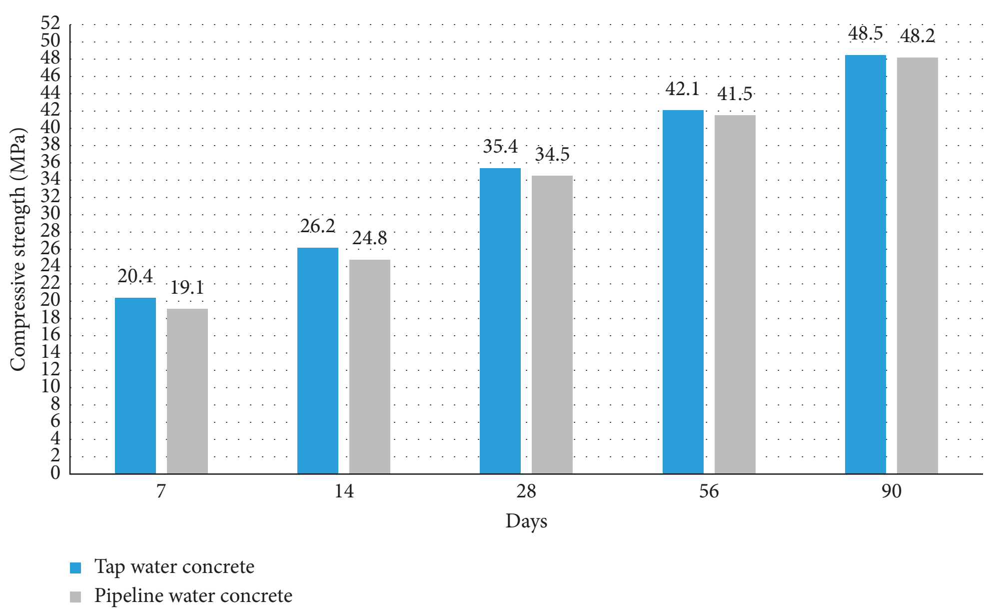

Figure 9: Comparison of compressive strength in tap water concrete and pipeline water concrete by replacing 50% of granite aggregate.

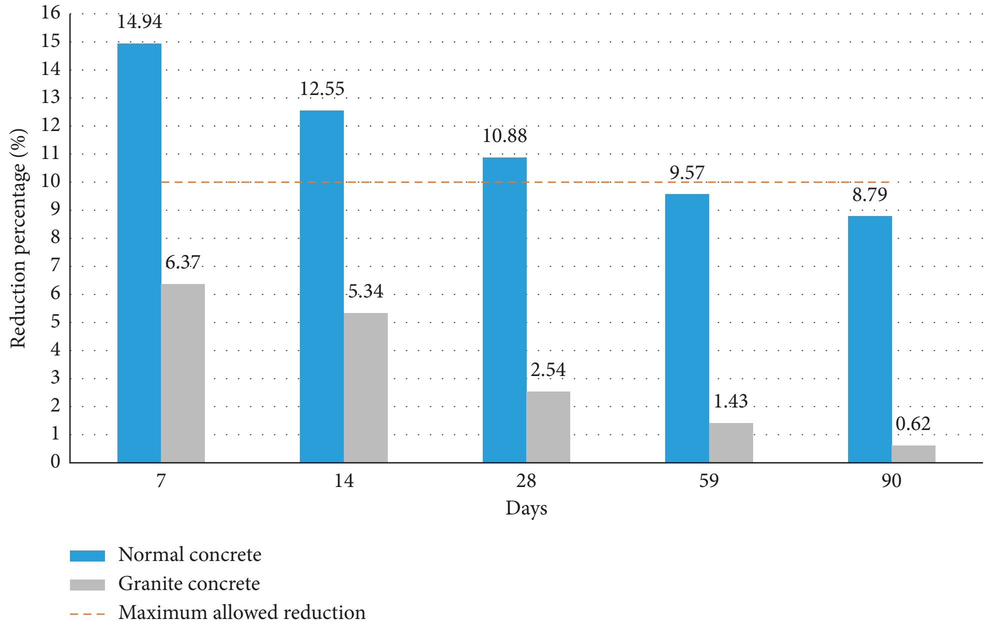

Figure 10: Percentage of strength reduction in the normal concrete and granite concrete with the maximum allowed limitation.

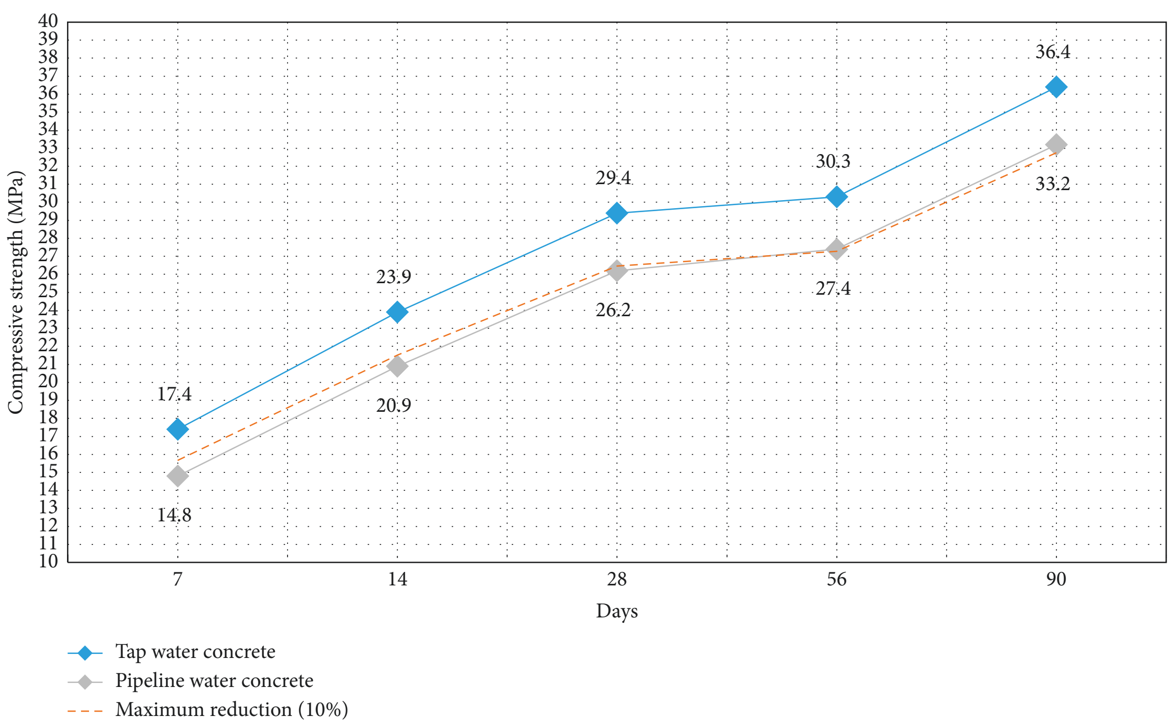

Figure 11: Comparative chart of compressive strength results for normal concrete samples made by using tap water and pipeline water.

showed less reduction in the strength by using pipeline water. There is more reduction on the initial days than on the final days but, for the normal concretes, the reduction percentage was higher compared to granite samples. This can also be the effect of granite aggregates on the shrinkage of samples or the influence of water ingredient on the aggregates. The percentage of the reduction in concrete strength has been shown in Figure 10 for normal concrete and granite concrete.

Figure 10 shows that the total amounts of reduction for granite concrete samples are less than 10% for all the stages. Also, these samples showed less reduction in strength over time. But, for normal samples, the reduction of strength was higher than the limitation on the initial days and it continued until the 56th day. Even at the final stage, the reduction of strength was still near to the upper limit and it can go higher with any intentional fault in concrete-making procedures.

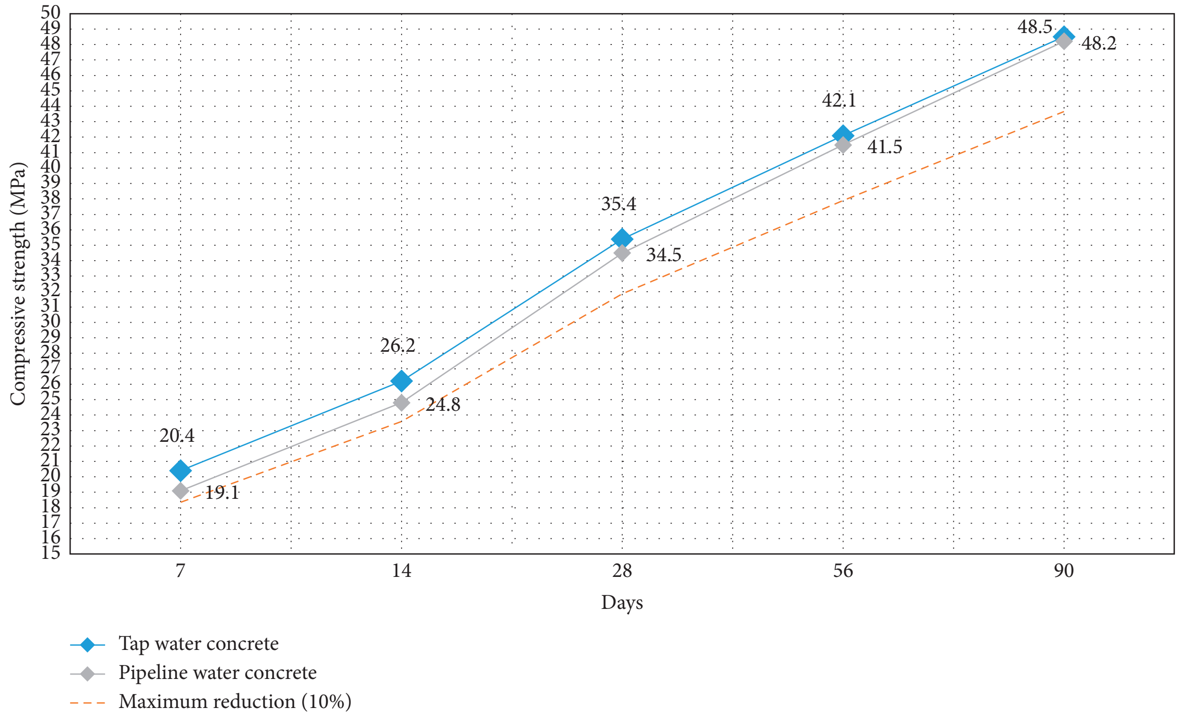

Figure 12: Comparative chart of compressive strength results for granite concrete samples made by using tap water and pipeline water.

The comparative charts of the compressive strengths of samples are shown in Figures 11 and 12 for normal concrete and granite concrete, respectively. The dashed line shows the maximum limit for each concrete mixture design. As a result, the compressive strength of normal concretes made by pipeline water is not acceptable in the initial days and it is very near to the lower limit of standard in the final stages. The standard strength is almost achieved on the 56th day. So any loading or proceeding of the construction must be stopped during this time. But by using the granite aggregates the reduction in the strength will be less and acceptable. This probably is the compensatory effect of granite on the weakness effect of pipeline water. Any other kind of reinforcement can be used for increasing the strength of the concrete in opposition to the weakness of pipeline water.

As a result, the use of normal water for making concretes in this city is not acceptable at least for the initial days and the concretes must be mixed with some reinforced materials for increasing the strength of the concretes. Also, the different type of cement may have an effect on the initial strength of concrete and increase it to be inside the limitations. Moreover, the effect of curing water must be studied on both mixed designs.

5. Conclusion

In this study, the effect of pipeline water of Larestan on the compressive strength of concretes has been investigated. Four groups of samples were made and tested to illustrate the effect of pipeline water on the concretes. Also, the granite aggregates were used as 50% replacement in concrete samples for their reinforcement with the purpose of increasing the strength. The achieved conclusions are as follows:

(1) The compressive strength of concrete made by using pipeline water is less than 90% of that of the same concrete made by using tap water and this is the opposite of the "concrete standard association." So, at this time, the concretes made in this city cannot satisfy the standard criteria.

(2) By replacing 50% of granite aggregates, the compressive strength of concrete increased by more than 12%. This increase was higher for the samples made by using pipeline water. As a result, 50% replacement of granite aggregates is suitable for standardizing the concretes made in this city by using the pipeline water.

(3) The effect of water on the strength reduction in the normal concrete was higher compared to that in granite concrete. It may be attributed to the damaging effect of pipeline water on the concrete strength which has been compensated by the granite aggregates. This reduction was more than 10% in the normal concretes (nonstandard) but for the granite concretes it was standard.

(4) In the case of using normal pipeline water concrete, any loading or proceeding of construction must be stopped during the first 56 days due to the lower strength value of normal pipeline water concrete in the initial days. But it can be seen that in this city the concretes will load just after 7 days.

Data Availability

The results of the compressive strength of the samples, broken samples pictures, and pictures of work procedure are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

Acknowledgments

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References

[1] M. A. Akinpelu, S. O. Odeyemi, O. S. Olafusi, and F. Z. Muhammed, "Evaluation of splitting tensile and compressive strength relationship of self-compacting concrete," *Journal of King Saud University—Engineering Sciences*, vol. 31, no. 1, pp. 19–25, 2019.

[2] R. Howes, M. N. S. Hadi, and W. South, "Concrete strength reduction due to over compaction," *Construction and Building Materials*, vol. 197, pp. 725–733, 2019.

[3] W. Piasta and B. Zarzycki, "The effect of cement paste volume and w/c ratio on shrinkage strain, water absorption and compressive strength of high performance concrete," *Construction and Building Materials*, vol. 140, pp. 395–402, 2017.

[4] J. Shen and Q. Xu, "Effect of moisture content and porosity on compressive strength of concrete during drying at 105°C," *Construction and Building Materials*, vol. 195, pp. 19–27, 2019.

[5] C. Chhorn, S. J. Hong, and S. W. Lee, "Relationship between compressive and tensile strengths of roller-compacted concrete," *Journal of Traffic and Transportation Engineering (English Edition)*, vol. 5, no. 3, pp. 215–223, 2018.

[6] T. Kim, J. M. Davis, M. T. Ley, S. Kang, and P. Amrollahi, "Fly ash particle characterization for predicting concrete compressive strength," *Construction and Building Materials*, vol. 165, pp. 560–571, 2018.

[7] S. R. Abid, A. H. Nahhab, H. K. H. Al-Aayedi, and A. M. Nuhair, "Expansion and strength properties of concrete containing contaminated recycled concrete aggregate," *Case Studies in Construction Materials*, vol. 9, Article ID e00201, , 2018.

[8] K.-M. Kim, S. Lee, and J.-Y. Cho, "Effect of maximum coarse aggregate size on dynamic compressive strength of high-strength concrete," *International Journal of Impact Engineering*, vol. 125, pp. 107–116, 2019.

[9] A. Younis, U. Ebead, P. Suraneni, and A. Nanni, "Fresh and hardened properties of seawater-mixed concrete," *Construction and Building Materials*, vol. 190, pp. 276–286, 2018.

[10] A. M. Ghrair, O. A. Al-Mashaqbeh, M. K. Sarireh, N. Al-Kouz, M. Farfoura, and S. B. Megdal, "Influence of grey water on physical and mechanical properties of mortar and concrete mixes," *Ain Shams Engineering Journal*, vol. 9, no. 4, pp. 1519–1525, 2018.

[11] S. A. Miller, A. Horvath, and P. J. M. Monteiro, "Impacts of booming concrete production on water resources worldwide," *Nature Sustainability*, vol. 1, no. 1, pp. 69–76, 2018.

[12] N. Su, B. Miao, and F.-S. Liu, "Effect of wash water and underground water on properties of concrete," *Cement and Concrete Research*, vol. 32, no. 5, pp. 777–782, 2002.

[13] P. R. de Matos, L. R. Prudêncio Jr., R. Pilar, P. J. P. Gleize, and F. Pelisser, "Use of recycled water from mixer truck wash in concrete: effect on the hydration, fresh and hardened properties," *Construction and Building Materials*, vol. 230, p. 116981, 2020.

[14] K. Meena and S. Luhar, "Effect of wastewater on properties of concrete," *Journal of Building Engineering*, vol. 21, pp. 106–112, 2019.

[15] T. U. Mohammed, H. Hamada, and T. Yamaji, "Performance of seawater-mixed concrete in the tidal environment," *Cement and Concrete Research*, vol. 34, no. 4, pp. 593–601, 2004.

[16] S. K. Kaushik and S. Islam, "Suitability of sea water for mixing structural concrete exposed to a marine environment," *Cement and Concrete Composites*, vol. 17, no. 3, pp. 177–185, 1995.

[17] N. Su and C.-F. Wu, "Effect of magnetic field treated water on mortar and concrete containing fly ash," *Cement and Concrete Composites*, vol. 25, no. 7, pp. 681–688, 2003.

[18] M. H. Dehghani, G. A. Haghighat, and M. Yousefi, "Data on fluoride concentration in drinking water resources in Iran: a case study of Fars province; Larestan region," *Data in Brief*, vol. 19, pp. 842–846, 2018.

[19] M. Anwar and M. Roushdi, "Improved concrete properties to resist the saline water using environmental by-product," *Water Science*, vol. 27, no. 54, pp. 30–38, 2013.

[20] P. Parthasarathy, A. Hanif, H. Shao, and Z. Li, "Microstructural and morphological studies of ordinary portland cement paste and fly ash based geopolymer in the presence of chloride ions," in *Proceedings of the International Conference on Advances in Construction Materials and Systems (ICACMS-2017)*, Chennai, India, September 2017.

[21] M. Balonis, B. Lothenbach, G. Le Saout, and F. P. Glasser, "Impact of chloride on the mineralogy of hydrated portland cement systems," *Cement and Concrete Research*, vol. 40, no. 7, pp. 1009–1022, 2010.

[22] D. Shi, Y. Yao, J. Ye, and W. Zhang, "Effects of seawater on mechanical properties, mineralogy and microstructure of calcium silicate slag-based alkali-activated materials," *Construction and Building Materials*, vol. 212, pp. 569–577, 2019.

[23] A. Alizadeh, "Assimilation of Iranian concrete code (ABA) compared to ACI code about the mechanical properties of HSC beams subjected to pure bending moment," in *Proceedings of the Third International Conference on Construction Materials: Performance, Innovations and Structural Implications*, p. 300, The University of British Columbia, Vancouver, Canada, August 2005.

[24] W. Shanks, C. F. Dunant, M. P. Drewniok, R. C. Lupton, A. Serrenho, and J. M. Allwood, "How much cement can we do without? Lessons from cement material flows in the UK," *Resources, Conservation and Recycling*, vol. 141, pp. 441–454, 2019.

[25] H. Ait-Aider, N. E. Hannachi, and M. Mouret, "Importance of W/C ratio on compressive strength of concrete in hot climate conditions," *Building and Environment*, vol. 42, no. 6, pp. 2461–2465, 2007.

[26] W. Chalee, M. Teekavanit, K. Kiattikomol, A. Siripanichgorn, and C. Jaturapitakkul, "Effect of W/C ratio on covering depth of fly ash concrete in marine environment," *Construction and Building Materials*, vol. 21, no. 5, pp. 965–971, 2007.

[27] M. Syarif, V. Sampebulu', M. W. Tjaronge, and Nasruddin, "Characteristic of compressive and tensile strength using the organic cement compare with portland cement," *Case Studies in Construction Materials*, vol. 9, Article ID e00172, 2018.

[28] U. G. Eziefula, J. C. Ezeh, and B. I. Eziefula, "Properties of seashell aggregate concrete: a review," *Construction and Building Materials*, vol. 192, pp. 287–300, 2018.

[29] A. C. I. Committee, *Building Code Requirements for Structural Concrete: (ACI 318-95); and Commentary (ACI 318R-95)*, American Concrete Institute, Farmington Hills, MI, USA, 1995.

[30] S. D. Kore and A. K. Vyas, "Impact of marble waste as coarse aggregate on properties of lean cement concrete," *Case Studies in Construction Materials*, vol. 4, pp. 85–92, 2016.

[31] S. Ghorbani, I. Taji, J. de Brito et al., "Mechanical and durability behaviour of concrete with granite waste dust as partial cement replacement under adverse exposure conditions," *Construction and Building Materials*, vol. 194, pp. 143–152, 2019.

[32] T. Felixkala and P. Partheeban, "Granite powder concrete," *Indian Journal of Science and Technology*, vol. 3, no. 3, pp. 311–317, 2010.

[33] H.-K. Liu, N.-H. Tai, and W.-H. Lee, "Effect of seawater on compressive strength of concrete cylinders reinforced by non-adhesive wound hybrid polymer composites," *Composites Science and Technology*, vol. 62, no. 16, pp. 2131–2141, 2002.

[34] T. I. M. Abdel-Magid, R. M. Hamdan, A. A. B. Abdelgader, M. E. A. Omer, and N. M. R.-A. Ahmed, "Effect of magnetized water on workability and compressive strength of concrete," *Procedia Engineering*, vol. 193, pp. 494–500, 2017.

[35] Institute of Standards and Industrial Research of Iran, "Drinking water—physical and chemical specifications," in *ISIRI 1053 5th Revision*, Institute of Standards and Industrial Research of Iran, Tehran, Iran, 2010.

[36] WHO, *Guidelines for Drinking-Water Quality*, vol. 1, World-Health Organization, Geneva, Switzerland, 3rd edition, 2008.

[37] Association, W. Q. The Degree of Hardness Standard.

[38] American Society of Agricultural and Biological Engineers, *Guidelines for Calibrating, Validating, and Evaluating Hydrologic and Water Quality (H/WQ) Models*, American Society of Agricultural and Biological Engineers, St. Joseph, MI, USA, 2017.


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