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Influence of zeolite on compressive strength, permeability and resistance to chlorine ion attack in concrete

B. Saeedi Razavi [*1], S. M. Rohani [2], M. Shiri [3], B. Mehdikhani [4]

Abstract

Corrosion is one of the destructive factors that causes a lot of damage to the reinforcement inside the concrete and causes irreparable damage to the economy. Chlorine ion penetration in concrete is one of the most important factors affecting concrete corrosion. Therefore, it is necessary to refine corrosion by identifying the concrete properties using proper methods. In this study, the effect of adding zeolite (0, 10 and 15%) to concrete on the uniaxial compressive strength and penetration rate of chlorine ion in concrete was investigated. According to the tests result performed by adding zeolite at the beginning concrete compressive strength decreases but after 90 days the compressive strength increases and is approximately equal to the strength of control samples. Zeolite also reduces the penetration rate of chlorine ions into concrete by 30% on average (compared to the control sample). Finally, it can be concluded that using 10% zeolite improves the concrete properties.

Keywords: *Concrete, Zeolite, Compressive strength, Chlorine ion, Corrosion.*

[1]. Research Assistant professor, Department of Construction and Mineral Engineering, Technology and Engineering Research Center, Standard Research Institute (SRI), Karaj, Iran
2. Postgraduated of civil engineering, director of durability department of concrete, Amin Nano Concrete Knowledge Co.
3. PHD Student, Department of Geology, Ferdowsi University of Mashhad.
4. Department of Construction and Mineral Engineering, Technology and Engineering Research Center, Standard Research Institute (SRI), Karaj, Iran
*** Corresponding Author** : bsaidi@standard.ac.ir

Extended Abstract:

1. Introduction

Concrete is always one of the most utilized materials in civil engineering due to its mechanical resistance and durability. Therefore, increasing the strength of concrete has always been the focus of concrete researchers. One of the major parameters for increasing the durability of concrete and structures is the improvement in corrosion resistance of reinforced concrete. The chloride ion penetration is one of the most significant causes of corrosion of reinforcement. The use of pozzolans is one of the methods to reduce the amount of chlorine ion in the concrete.

2. Materials and methods

The Persian Gulf region contains corrosive soils and high salinity water. Due to the importance of the structures being built in this area, the use of low corrosion concrete to reduce damage and maintain resistance is of great interest. Therefore, this study examines the effect of using zeolite on improving concrete engineering properties to increase its strength against corrosion.

Table1. Mix design plan

Design code	W/C	C (kg/m^3)	Zeolite (%)	Fine grain (S) (kg/m^3)	Coarse grain (G) (Kg/m^3)	S/G	water (kg/m^3)	Slump (cm)
300-0	0.64	300	0	914.55	944.81	0.96	192	8
300-10	0.66	270	10	883.2	949.7	0.93	198	8.5
300-15	0.68	255	15	872.92	938.65	0.93	204	8.5
325-0	0.62	325	0	865.64	938.52	0.92	201.5	12
325-10	0.64	292.5	10	851.88	923.6	0.92	208	11
325-15	0.66	276.25	15	847.74	911.19	0.93	214.5	13
350-0	0.57	350	0	847.04	947.68	0.89	199.5	9
350-10	0.6	315	10	828	926.38	0.89	210	10
350-15	0.62	297.5	15	807.72	915.63	0.88	217	8
375-0	0.56	375	0	815.03	924.64	0.88	210	12.5
375-10	0.58	337.5	10	805.53	904.17	0.89	217.5	13
375-15	0.61	318.75	15	788.3	884.83	0.89	228.75	13.5
400-0	0.51	400	0	815.63	919.26	0.88	204	11.5
400-10	0.53	360	10	797.48	901.08	0.88	212	8
400-15	0.56	340	15	776.44	880.42	0.88	224	10.5
425-0	0.49	425	0	759.3	902.98	0.88	208.25	9
425-10	0.52	382.5	10	772.47	876.98	0.88	221	8.5
425-15	0.55	361.25	15	751.4	852.8	0.88	233.75	11
450-0	0.48	450	0	776.63	878.28	0.88	216	12.5
425-10	0.51	405	10	751.02	851.6	0.88	229.5	12
425-15	0.53	382.5	15	736.15	834.71	0.88	238.5	14

In the use of zeolite, it should be noted that, on the one hand, zeolite reduces the penetration of chloride ions, and on the other hand, it does not reduce the compressive strength (or other properties) of the concrete excessively. To achieve this purpose, twenty-one concrete mix designs were made using Delijan Type 1-425 Cement. In this mixing design, cement content of 300, 325, 350, 375, 400, 425 and 450 kg/m3 and zeolite content of 0, 10 and 15% were used. Zeolite-free samples were considered as control samples. In the mixing design, the only zeolite was used as a concrete additive and no other chemical additive was used in the concrete. In the next step, experiments were performed on samples of different ages.

3. Tests results

During this study 105 compressive strength tests (ages 7, 28, and 90 days), 63 water absorption tests (ages 90 days), 126 electrical resistivity tests (ages 7, 14, 28, 42 and 90 days) and 42 rapid chloride migration

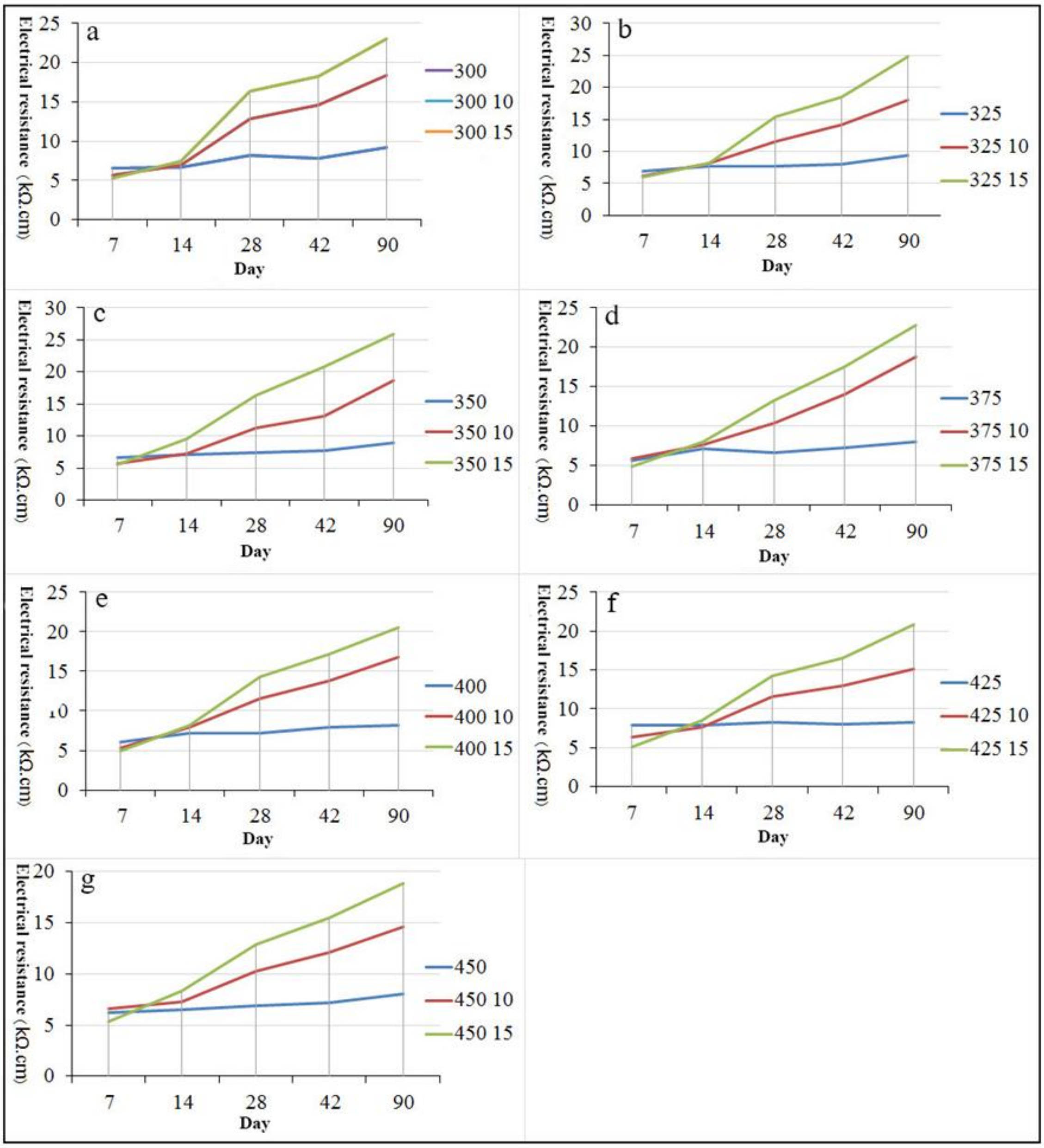

Fig 1. Result test of Electrical resistance

tests (RCMT) (ages 28 and 90 days) were carried out. Finally, the results of the experiments were analyzed. Overall, the strength of the control samples increased with increasing cement content and age. At the age of seven days, for 10% zeolite samples, the compressive strength of concrete declined by 9.3 to 18.9% and for samples with 15% zeolite, it reduced by 19.5 to 28.3%. However, as the concrete age increased, the negative effect of zeolite on concrete compressive strength decreased. So that the strength of concrete samples with 10% zeolite at 90 days is approximately equal to that of control samples. Also, for samples with 15% zeolite, the rate of resistance drop was reduced by 3 to 16%. Adding 10% zeolite increased the water absorption rate and the amount of cavity by 1.07 to 1.32% (mean 1.15%) and 1.08% to 1.19% (mean 1.12%) respectively. For samples with 15% zeolite, the amount of concrete cavity increased between 1.15 to 1.29% (mean 1.22%) and the water absorption rate climbed by 1.13 to 1.37% (mean 1.25%). A comparison of the electrical resistivity of zeolite samples with control samples at 90 days shows that in samples containing 10% and 15% zeolite, on average 100% and 160% increase in electrical resistivity was observed respectively. Analyzes on concrete samples showed that the rate of chloride ion penetration decreased from 28 days to 90 days, for control samples by 98.4% to 116% (mean 108%), for samples with 10% zeolite up to 114.3%. to 158.1% (median 138.1%) and for samples with 15% zeolite 154.5 to 188% (median 138.3%) obtained. So it can be stated that by adding zeolite, Chlorine ion penetration is reduced by an average of 30%.

4. Conclusion

Finally, it can be said that the use of 10% zeolite in long-term ages has a better effect on increasing the compressive strength of concrete. Also, the use of 10% zeolite increases the amount of cavity and water absorption of concrete compared to 15% zeolite, but the use of 15% zeolite has a greater impact on increasing the electrical resistivity of the concrete and thereby increasing the resistance of concrete and reinforcement against chloride ion penetration. It should be noted that the use of 300 to 375 kg of cement and zeolite has a better effect on increasing the strength of concrete and by increasing the weight of cement and zeolite to more than 375 kg the strength of the specimens decreased.

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