Compressive Strength of Brick Aggregate Concrete using Saline Water

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Abstract

This study presents the results of the experimental research of the effect of salts in mixing water on compressive strength of brick aggregate concrete. Concrete cylindrical specimens (150 mm × 300 mm) were made using fresh and salt water with mix ratio 1:1.5:3. All the mixes were prepared using constant water cement ratio (w/c) of 0.5 by weight. A total of 108 concrete cylinders were made. NaCl concentration of 0 g/l, 15 g/l, 25 g/l, 35 g/l, 45 g/l and $MgSO_4$ concentration of 0 g/l, 0.5 g/l, 1.0 g/l, 1.5 g/l, 2.0 g/l of water were used as salt with fresh water. All the specimens were cured in fresh water for 7, 28, 56 and 90 days. Then these specimens were crushed using the compressive strength test apparatus. The study showed that the compressive strength of concrete increased at early ages but decreased at long time periods in case of concrete made using NaCl. But compressive strength of concrete decreased when the specimens were made using $MgSO_4$ at all ages. The study also shows the decrease in the long term compressive strength of concrete for both NaCl and $MgSO_4$.

Keywords: *Brick aggregate concrete, Compressive strength, Saline water, NaCl, $MgSO_4$.*

1 Introduction

Concrete is mainly used to provide higher resistance against compression by its suitable compressive strength. The compressive strength of concrete depends on the several factors such as concrete ingredients, quality control, environmental factor etc. One of the most important ingredients is water which affects the compressive strength of concrete. The compressive strength of concrete may be affected when different salt concentration present in the water which is used in preparation of concrete. In coastal areas this water quality affected by different salts dissolved in it. Also in other area due to the environmental and industrial effects, water can contain different salts and other impurities. These different types of salt react with the hardened concrete. These salts are chloride and sulfate of sodium, magnesium and ammonium. These several types of salt can affect the compressive strength of concrete. The bulk of the concrete consists of fine and coarse aggregate. Cement and water interact chemically to bind the aggregate particle into a solid mass. So water is very important ingredient to react with cement. For good hydration of cement and workability consideration quantity and quality of water is one of the important factor. Most of the concrete is prepare by using fresh water. Fresh water is that in which harmful agents present in water in allowable limit. One of the important agents is dissolved salt present in water. The dissolved salt exceeding allowable limit is called saline water. Seawater contains various salts and attacks the concrete and reduces the strength. In addition the chemical action forms crystallization of the salts in the pores of the concrete may result in its disruption owing to the pressure exerted by the salt crystals. Because crystallization takes place at the point of evaporation of water, this form of attack occurs in the concrete above the water level (Rao et. al. 2012). However, the salt solution rises in the concrete by capillary action, the attack takes place only when the water can penetrate into the concrete so that impermeability of the concrete is once again it's most important attribute. Seawater has a total salinity of about 3.5% (78% of the dissolved solids being NaCl and 15% $MgCl_2$ and $MgSO_4$), and produces a slightly higher early strength but a lower long-term strength (Abrams 1924). A review of literature reveals that the study reported by Arunakanthi et al. (2013) for the effects of magnesium sulfate in mixing and curing water on strength of high-performance metakaolin concrete. In their study test results shows that the compressive strength decreased with the increase in concentration of $MgSO_4$ in mixing and curing water and also compressive strength decrease as the curing period increase for later ages of curing i.e. 7 days, 28 days, and 90 days for all concentrations of $MgSO_4$. According to Mbadike and Elinwa (2011), use of salt water in concrete production reduces the strength of concrete approximately 8% and the presence of chlorides and sulfates in salt water reduces strength of concrete. Abalaka and Babalaga (2011) studied the effect of sodium chloride solutions on compressive strength development of concrete containing rice husk ash. Authors have explained that NaCl solutions have compressive strength

accelerating properties at early ages that cannot be sustained long term. Teja et al. (2014) reported that small amount of salinity in mixing water improve the compressive strength. Umoh (2012) investigated the effect of different sulfate types and concentrations on compressive strength of periwinkle shell ash blended cement concrete. Their study represented that strength loss increases as the concentration of the sulfate increases from 1% to 5% concentration, and exposure period from 62 days to 152 days and have a greater effect for 5% concentration and exposure period of 152 days on compressive strength. Another study (Oladapo and Ekanem 2014) reported the effect of sodium chloride (NaCl) on concrete compressive strength. Authors have concluded that sodium chloride could be used as additive in plain concrete work at between 2 and 6 percentages if there is need to improve or increase the compressive strength of concrete.

In actual practice most of the concrete production is done with natural water source. So this source can contain salinity which may interrupt the compressive strength of concrete. Therefore, the aim of this research was to investigate how salinity can affect the compressive strength of brick aggregate concrete.

2 Materials and Methodology

This study was set to investigate the variation of compressive strength of brick aggregate concrete made using saline water. Various salt contents of NaCl (15 g/l, 25 g/l, 35 g/l and 45 g/l) and $MgSO_4$ (0.5 g/l, 1.0 g/l, 1.5 g/l and 2.0 g/l) had been used with fresh water as salinity for mixing of concrete. A mixture of local sand and Sylhet sand (1:1) was used as fine aggregate and 25 mm downgrade brick chips was used as coarse aggregate with a mix ratio of 1:1.5:3 and w/c ratio of 0.5. Standard cylindrical specimen (150 mm × 300 mm) were prepared and compressive strength was tested after continuously immersed under normal water for 7, 28, 56 and 90 days. In all cases Composite Portland Cement was used. It is a fact that the properties of concrete ingredients have influence on the properties of concrete. Under the experimental investigation, physical properties of materials were evaluated and given in Table 1.

Table 1: Properties of concrete ingredients

Properties	Fine aggregate		Coarse aggregate
	Local sand	Sylhet sand	25 mm downgrade
Bulk specific gravity (SSD)	2.66	2.69	1.98
Water absorption (percent of dry weight)	1.63	3.01	17.00
Fineness Modulus	1.57	2.82	6.61
Unit weight, kg/m^3 (dry, compacted)	1651	1698	962

2.1 Preparation of specimens

The graded aggregates (both fine and coarse aggregates) were soaked in water for 24 hours air-dried to saturated surface dry (SSD) condition before mixing with other ingredients. For each mix, all of the ingredients with appropriate proportions were added in the mixture machine and then mixing was done for about 2 minutes. The test specimens were cast in steel moulds and compacted with a tamping rod. They were demoulded 24 hours after casting and were cured under water until 24 hours before the test.

2.2 Testing of specimens

The specimen were taken out of water approximately 24 hours before testing and were kept in the air dry condition in the laboratory. The concrete cylinders of different variable were tested for compressive. Total 108 numbers of specimen were tested following appropriate ASTM standard.

3 Test Results and discussions

3.1 Variation of compressive strength with NaCl concentrations

The results of the variation of compressive strength of brick aggregate concrete made with various concentration of NaCl are shown in Fig. 1 for 7, 28, 56 and 90 days. It can be seen that the compressive strength of concrete increased with increase the salinity content at early ages and decreased at long ages. This may due to the increase the mass density of the concrete. At early ages NaCl react with silica and alumina of cement during hydration period and produce a complex compound paragonite (a crystal structure) which fill the pores of concrete and produce denser concrete hence increase the strength and at long term internal stress developed in the crystal hence reduce the strength (Rao et. al 2012). At 7, 28 and 56 days 11% - 31%, 6% - 18% and 1.3 to 7.3% compressive strength increased with increase the NaCl concentration of 15 g/l to 45 g/l respectively. But at 90 days compressive

strength of concrete decreased by 8% - 27% for NaCl concentration of 15g/l to 45g/l. It is also observed that compressive strength of concrete increased at early ages but decreased at long term ages.

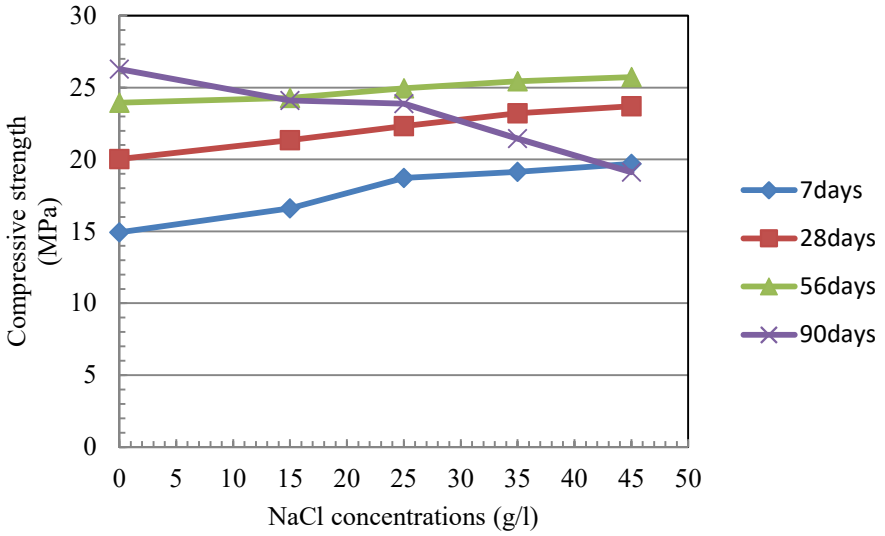

Figure 1: Variation of compressive strength with NaCl concentrations

3.2 Variation of compressive strength with $MgSO_4$ concentrations

The results of the variation of compressive strength of brick aggregate concrete made with various concentration of $MgSO_4$ is presented in Fig. 2 for 7, 28, 56 and 90 days. The results show that the compressive strength of concrete decreased with the salt content of $MgSO_4$. This is due to the presence of $MgSO_4$ in water which formed a new compound named Sepiolite ($(Mg_4SiO_5(OH)_2.6H_2O)$). At 7, 28, 56 and 90 days age of concrete percentages of compressive strength decreased 5.5% to 22%, 10% to 24%, 2% to 11% and 11% to 22% with the $MgSO_4$ concentration from 0.5g/l to 2.0g/l respectively. It is observed that compressive strength of concrete rapidly decreased at all ages with $MgSO_4$ concentration.

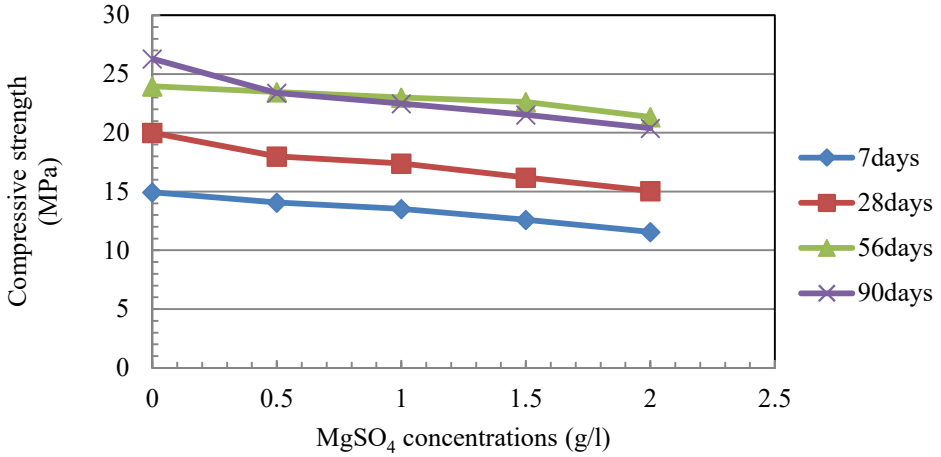

Figure 2. Variation of compressive strength with MgSO4 concentrations

3.3 Variation of compressive strength with age

From Fig. 1 and Fig. 2 it is observed that in all cases the compressive strength of concrete increase at 7, 28 and 56 days but decrease at 90 days for both NaCl and $MgSO_4$. For a NaCl concentration of 15 g/l, the compressive strength of concrete increased 11%, 6% and 1.3% at 7, 28 and 56 days ages but decreased 8% at 90 days compared to control concrete. At 25 g/l NaCl concentration strength increased 25%, 11.5% and 4.2% at 7, 28 and 56 days age of concrete and decreased 9% at 90 days. For 35 g/l NaCl concentration strength increased 28%, 16% and 6% at 7, 28 and 56 days age of concrete and decreased 18% at 90 days. For 45 g/l NaCl concentration strength increased

31%, 18% and 7% at 7, 28 and 56 days but decreased 27% at 90 days. On the other hand, for a $MgSO_4$ concentration of 15 g/l strength decreased 5.5%, 10% 2%, and 11% at 7, 28, 56, and 90 days ages and for 1.0 g/l $MgSO_4$ concentration strength decreased 9%, 13%, 4%, and 14% at 7, 28, 56, and 90 days age of concrete. At 1.5 g/l $MgSO_4$ concentration strength decreased 15%, 19%, 5.5%, and 18% at 7, 28, 56, and 90 days age of concrete. For 2.0 g/l $MgSO_4$ concentration strength decreased 22%, 25%, 11%, and 22% at 7, 28, 56, and 90 days age of concrete.

4 Conclusions

The experiments were conducted to study the variation of compressive strength with different salt concentration of NaCl and $MgSO_4$ in production of brick aggregate concrete. On the basis of the experimental observations and discussions the following conclusions are drawn:

- NaCl as salinity in mixing water increased the early strength and decreased the long term compressive strength of brick aggregate concrete.
- $MgSO_4$ as salinity in mixing water decreased the compressive strength of brick aggregate concrete at all ages.
- The compressive strength of concrete increased at 7, 28 and 56 days but decreased at 90 days for both NaCl and $MgSO_4$.

References

Abalaka, A.E. and Babalaga,A.D. (2011). Effects of Sodium Chloride Solutions on Compressive Strength Development of Concrete Containing Rice Husk Ash. ATBU Journal of Environmental Technology, 1(December), pp.33-40.

Abrams, D. (1924). American Concrete Institute, No. 20, pp. 422.

American Society for Testing and Materials (2001). Annual Book of ASTM Standards, West Conshohocken, PA, USA, Vol. 04.02.

Arunakanthi, E., Sudarsana Rao, H. and Ramanareddy, I.V. (2013). Engineering Effects of Magnesium Sulphate in Mixing and Curing Water on Strength of High-Performance Metakaolin Concrete. Global Research Analysis International, Vol. 2, pp.64-67.

Mbadike, E.M. and Elinwa, A.U. (2011). Effect of Salt Water in the Production of Concrete. Vol. 30, No. 2.

Oladapo, S.A. and Ekanem, E.B. (2014). Effect of Sodium Chloride (Nacl) on Concrete Compressive strength. Vol. 3, No. 3, pp.2395-2397.

Rao, D.S, Reddy, R. and Bhaskar, S.V. (2012). Influence of Neutral Salts (Nacl and KCl) in Water on Properties of Natural Admixture Cements. Engineering Science and Technology: An International Journal (ESTIJ), ISSN: 2250-3498, Vol. 2, No. 4, pp. 745-751

Teja, G.S., Amar, B.P., Manoj, N.R., Venkatesh, E. and Tenepalli, P. (2014). Study of Compressive Strength of Concrete Made Using Saline Water. International Journal of Civil and Structural Engineering Research, Vol. 2, No. 1, pp.76-78.

Umoh, A.A. (2012). Effect of Different Sulphate Types and Concentrations on Compressive Strength of Periwinkle Shell Ash Blended Cement Concrete. No. 5.