Experimental Study on Concreting with Naturally Available Salty Water or Hardwater Using Concare B-14

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"EXPERIMENTAL STUDY ON CONCRETING WITH NATURALLY AVAILABLE SALTY WATER OR HARDWATER USING CONCARE B-14"

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ABSTRACT

Concrete is a unique modern construction material which needs water in an excess quantity. Corrosion of reinforcing steel in a concrete structure is a common problem. Chlorides and other salts in water induce corrosion, which is one of the main mechanisms of deterioration affecting the long-term performance and serviceability of concrete structures. This research paper aims to minimize the corrosion and permeability of concrete with saline water a substitute for potable water and utilize the industrial wastes fly ash and sodium silicate, without affecting the property and durability of concrete. In the present research two grades of concrete M20 and M30 as per IS-10262:2019 are used for experimental analysis using an anti-corrosive and salinity neutralizing agent (CONCARE B-14). The CONCARE B-14 is used for concrete in the presence of hard water especially saline water. We have followed the IS methods for casting and to determine routine tests for the fresh and hardened state. The CONCARE B-14 is a physical mixture of fly ash and sodium silicate in a fixed proportion. Saline water contains more aggressive concentrations of chloride, sulphates and different pH which is more vulnerable to corrosion compared to potable water. In this study, we are utilizing the industrial waste combinations of fly ash and sodium silicate in the concrete by using hard water or saline water which will be an alternative to potable water. The dry fly ash resists the chloride attack which can affect the durability of concrete and sodium silicate improves the alkalinity of the concrete mass and effectively protects reinforcement bars from getting corroded for a long time. We examined the compressive strength results and it shows that we can use saline or hard water as a substitute for portable water by using CONCARE B-14 as an anti-corrosive and salinity neutralizing agent.

Keywords-- Fly ash, sodium silicate, neutralizing agent, compressive strength, anti-corrosive.

INTRODUCTION

The world is growing and developing at an extra-ordinary pace. These growth measures extensively need concrete, as per the available statistical data, about 2 billion tons of concrete is manufactured all around the world every year. The water is a major constitute of concrete, which should be of potable quality. Water other than that of potable quality contains salts which can affect a durability of concrete and can cause the corrosion of reinforcement in the concrete. Concrete cannot be manufactured without water of potable quality. The earth contains 75% water and 25% area of land. Majority of the 75% of water is in sea, which is highly saline. The potable water is just 1% and it must be saved. The mankind consumes potable quality water at a very high rate for all purposes including developmental activities. Further it becomes inevitable to save water. The water consumed for manufacture concrete in one year worth of concrete is 33, 33, 33,333. And the quantity of water consumed for concreting near sea shore is worth consumption of potable water by 5,45,45,454 per year all around the world. The water containing high salts or high salt water can be actively considered or used as an alternate for the making of the concrete, as it is present in abundance. The salty water mainly consists of the chloride salts. The pH of salty water is in acidic range. The salty water or high salt water mainly comprises oxygen, hydrogen, chloride, sodium, magnesium, sulfur, calcium, potassium, chlorine and carbon. There are problems posed by the high salts water, when this water is used in the manufacture of concrete. The high salt water reacts with the metals because of its chemical characteristics. When the high salts water is used in the preparation of the concrete, the salty water reacts with the iron or steel rods or reinforcements. Further the chlorides present in the high salts water leads to a corrosion of the steel rods or iron rods. The concrete ages fast and the structure become weak over a period of time. Hence the high salt water cannot be directly used for the concrete preparation.

Fly ash is also known as flue ash. It is one of the residues generated in combustion and comprises fine particles that rise with the flue gases. Fly ash is an industrial waste produced after the combustion of coal. The disposal of fly ash is a challenge. Fly ash mainly consists of aluminium oxide ($A1_20_3$), Iron oxide (Fe_20_3), titanium dioxide ($Ti0_2$), silicon dioxide ($Si0_2$) and calcium oxide (CaO). Fly ash also consists of arsenic, beryllium, boron, cadmium, chromium, cobalt, lead, manganese, mercury, selenium, strontium, thallium and vanadium. Fly ash further contains dioxins and PAH compounds. These heavy metals make the fly ash, toxic. Earlier the fly ash was generally released into atmosphere, but a pollution control requirement mandates the capture of fly ash prior to release. In the present-day scenario, the fly ash is used to produce hydraulic cement or hydraulic plaster or partial replacement for Portland cement in concrete production. The use of fly ash in the concrete production solves two purposes. The use of fly ash in the concrete production reduces the fly ash in nature, and hence solves the problem of pollution. Further the use of fly ash reduces the cost of cement or concrete production.

Sodium silicate is the common name for compounds with the formula Na_2 ($Si0_3$) n. Sodium silicate is also known as water glass or liquid glass. Sodium silicate is available in aqueous solution and in solid form. Sodium silicate is also an industrial by product or waste. Sodium silicate is a white powder and it is readily soluble in water and produces an alkaline solution.

Sodium silicate finds its applications in many areas, but the application of sodium silicate for treating concrete is well known. Concrete treated with a sodium silicate solution helps to significantly reduce porosity in most masonry products such as concrete, plasters etc. The chemical reaction of cement with sodium silicate binds the silicates with the surface and makes the concrete more durable with water resistance. Sodium silicate is alkaline in nature and hence it increases alkalinity in concrete mass. Also, the inert value of sodium silicate is high. The inclusion of sodium silicate in concrete mix increases the alkalinity around the reinforcement steel bars placed inside the concrete. This results in the protection of the steel bars from corrosion as the reaction from high salt water.

Hence there is a need to develop a chemical composition for utilizing the high salt water for concrete production. Also, there is a need for a chemical composition utilizing industrial waste i.e., fly ash which has serious disposal problem for concreting with high salt water. “. The CONCARE B- 14 is an anti-corrosive and salinity neutralizing agent. The CONCARE B-14 consists of dry fly ash, [collected from Electro Static Precipitator (ESP)] and sodium silicate (Na_2Si0_3). The CONC ARE B-14 consists of fly ash and sodium silicate, both of which are industrial waste products. The dry fly ash is available from the industries having coal fired boilers. The sodium silicate is also available as the industrial by-product. This makes the availability of fly ash and sodium silicate at an economical rate. The CONC ARE B-14 consists of fly ash and sodium silicate in the ratio of 25:3 respectively. The CONCARE B-14 is produced by mixing both the fly ash and sodium silicate in the desired ratios, which is at par with the cement. This makes the cost of CONCARE B-14 manufacturing and packaging low. The CONCARE B-14 mixed with saline water prior to its mixing with concrete mass, makes the chlorides of high salt water to react with alumina present in CONCARE B-14 and hence its detrimental effects get nullified and when saline water mixed with CONCARE B-14 is added in concrete mixture, there is no detrimental effect of saline water to react with alumina of cement during hydration process.

The first step is preparing a dry concrete mixture. Simultaneously a mixture of an anti-corrosive and salinity neutralizing agent and the saline water is prepared. The next step is mixing the concrete mixture and the mixture of the anti-corrosive and salinity neutralizing agent and the high salt water to obtain a homogeneous concrete mixture with high salt water. The concrete mixture is casted into a plurality of structures and the strength is analyzed. The method of preparing an anti-corrosive agent and salinity neutralizing agent mixture comprising the following steps. The anti-corrosive agent and salinity neutralizing agent with high salt water are mixed in a pre-determined proportion. The anti-corrosive agent and salinity neutralizing agent is a physical mixture of a fly ash and a sodium silicate. The fly ash and the sodium silicate are in a ratio of 25:3, preferably in a ratio of 90:10. The anti- corrosive agent and salinity neutralizing agent and the saline water are preferably mixed for 30 minutes

LITERATURE SURVEY

The literature on effects of saline salts on the concrete and steel are available and studied. Other similar research paper related to use of various industrial waste such as fly ash and sodium silicate and the effect of this industrial waste on concrete and its steel reinforcement are written and studied.

In 1975 the bulletin by T. E. Larson published essential data on corrosion gathered by the Illinois State Water Survey in isolated or programmed studies, and from experience at state institutions since 1950, are summarized. A brief review of basic fundamentals of corrosion is presented as background for the summaries. Some general and specific recommendations concerning inhibitors and construction materials that were developed through laboratory and field evaluations for use by architects, engineers, and institutional maintenance personnel are also included in this study. It also contains a discussion of corrosion in water wells and pumps and two ancillary papers for orientation and recognition of other factors related to distribution system water quality.

The research study in 2004 by Jingyao Cao, et.al. studies electric polarization in cement-based materials (without conductive admixture) under an applied DC electric field was found by apparent electrical resistance measurement to be faster than subsequent depolarization under a reverse field by a factor ranging from 5 to 8. The slow depolarization suggested a degree of ionic trapping. In contrast, depolarization was even faster than polarization in carbon fiber cement, due to the fast whole response. Sand addition slowed down polarization saturation, but enhanced the polarization. Silica fume addition did not slow down polarization saturation, but diminished the polarization slightly. An increase in temperature enhanced the polarization due to increase in ionic mobility.

During 2016 Hee Jun Yang, et.al. investigated, studied and described the transportation of chloride in different types of high alumina cement (HAC) mortar. They utilized three HAC cement types which were, ranging from 52.0 to 81.1% of aluminium oxides in clinker. Setting time of fresh mortar was measured immediately after mixing to know the development of the strength, the mortar compressive strength was measured at 1–91 days after curing in a wet chamber at 25 ± 2∘C and then. To assess the rate of chloride transport in terms of diffusivity, the chloride profile was performed by an exposure test in this study, which was supported by further experimentation including an examination of the pore structure, chloride binding, and chemical composition (X-ray diffraction) analysis. As a result, it was found that an increase in the Al2O3 content in the HAC clinker resulted in an increase in the diffusion coefficient and concentration of surface chloride due to increased binding of chloride. However, types of HAC did not affect the pore distribution in the cement matrix, except for macro pores.

In 2018 Sajjad Ali Mangi et.al**.** focused on influence of ground CBA on strength performances of concrete exposed to sulphate and chloride environment. In this study the OPC was replaced with 10% of coal bottom ash by weight of cement and same water to binder ratio of 0.5 was used in all concrete mixes. The short-term effects of sulphate and chloride on the concrete were evaluated in terms of change in weight, variation in compressive strength and degree of damage. It was observed that the addition of CBA in concrete, gives the significant development in compressive strength, around 11.32% and 13.92% higher strength than that of the control mix in water and 5% Na2SO4 solution respectively at the exposure period of 90 days. This study suggests that 10% of CBA as a supplementary cementitious material in concrete could reduce negative effects of sulfate and chloride salts. The outcome of this study indicated that application of ground CBA as supplementary cementitious material in concrete increases the resistance against aggressive environment.

In 2019 Pawel Sikora1 et.al. investigates the effects of seawater and colloidal silica (NS) in the 1, 3 and 5 % weight respectively, on hydration, strength development and microstructural properties of Portland cement pastes. The information tells that seawater has an accelerating effect on cement hydration and thus a significant contribution to early strength development was observed. The advantageous effect of seawater was reflected in an improvement in compressive strength for up to 14 days of hydration, while in the 28 days compressive strength values were comparable to that of cement pastes produced with demineralized water. The combine effect of seawater and NS significantly promotes cement hydration kinetics due to a synergistic effect, deriving in higher calcium hydroxide (CH) production. NS will thus react with the available CH through the pozzolanic reaction and produces more C-S-H gel. A noticeable improvement of strength development, as the result of the synergistic effect of NS and seawater, was therefore observed. In addition, mercury intrusion porosimetry (MIP) tests confirmed significant improvements in microstructure when NS and seawater were combined, resulting in the production of a more compact and dense hardened paste structure. The optimal number of NS to be mixed with seawater, was found to be 3 wt% of cement.

Recently in 2020 Damyanti G. Badagha, et.al**.** studied whose study is based on construction of any structure extensively involves water. Water is required during construction – for preparation of concrete or mortar or wetting bricks etc. and also during post construction stage – for curing and other finishing activities. Quality of water grossly matters – directly or indirectly on the ultimate quality of construction. It is hence very categorically specified in respective Codes and Standards about the required quality of water to be used for construction activities. Substandard quality of water results in damage or deterioration of constructed structure. It is a known fact that any damage is a chemical process. Construction with poor quality of water imparts unhealthy reaction between its contaminating chemicals and other ingredients of construction materials used for that particular construction. With chemical reactions causing deterioration due to poor quality of ingredients of construction materials, chemistry involved in these reactions is required to be addressed. Thus, it is extremely essential to assess chemistry of damages to arrive at root cause of damage then its remedial measures. This paper discusses effects of poor quality of water used for construction activities and their remedial measures.

AIM AND OBJECTIVE

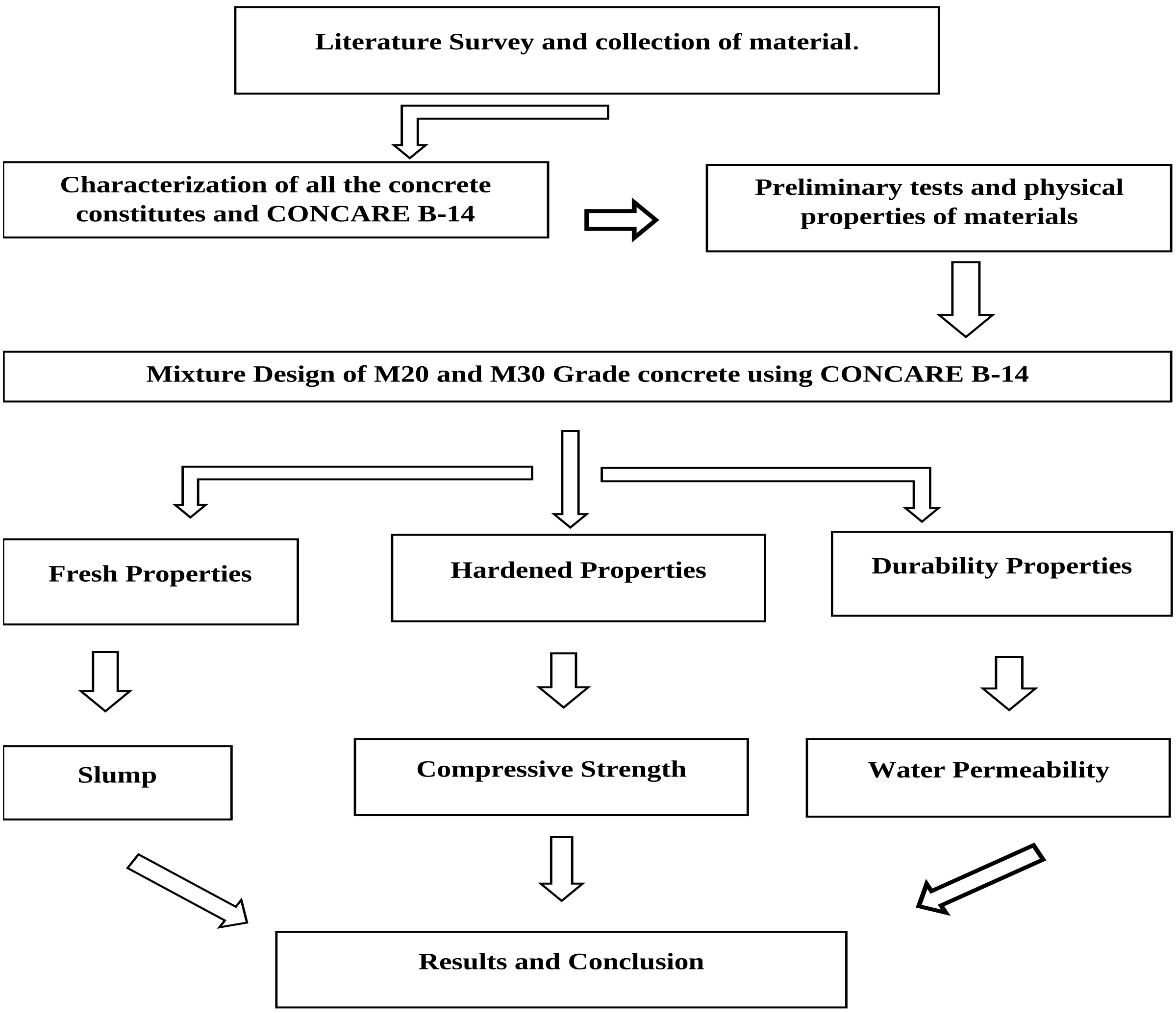
The aim of this research to study the performance, properties and strength of concrete of various grades using the CONCARE B-14. This experimental study will help to understand the behavior of fresh and hardened state of concrete made with CONCARE B-14.

The specific objectives of the present research work are:

1. The primary objective of the present research is to utilize a CONCARE B-14 comprising fly ash and sodium silicate for the preparation of concrete mix with water containing high salts
2. To use and study a concrete made by using CONCARE B-14 prepared with high salt water without changing the basic properties of concrete.
3. To study and observe concrete mixture made by addition of CONCARE B-14 with saline water without changing the durability and the property of corrosion resistance to the reinforcement.

For the study, we are going to perform compressive strength test on M20 and M30 grade of concrete by using CONCARE B-14 as an anti-corrosive and salinity neutralizing agent.

RESEARCH METHODOLOGY



Experimental Details:

- ### **Materials and Procedure**:

Here in this experimental study, we have used CONCARE B-14 as neutralizing agent, with hard water for two grades mainly M30 and M20. In this study we have mix design of concrete referring IS 10262:2019 given in Table 1. We have used locally available coarse aggregate, fine aggregate, OPC 43 grade cement and hard water. Then tests were conducted to determine compressive strength of M30 and M20 grade of concrete.

Table 1: Mix Design of M30 and M20 grade of concrete

Materials	**Cement**	**Fine Aggregate**	**10 mm**	**20 mm**	**Hard Water**	**Admixture**	**CONCARE B-14**
	Kg/m^3	**Kg/m^3**	**Kg/m^3**	**Kg/m^3**	**Kg/m^3**	**%**	**Kg/m^3**
M30	350	891	459	697	147	1.1	35
M20	300	923	460	692	155	0.4	30

Concrete mix design for M30 and M20 were prepared, CONCARE B-14 is used by 10% weight cement content. The mix was tested for fresh and hardened state and cubes were casted and cured. These cubes were tested to determine the compressive strength for 7 days and 28 days

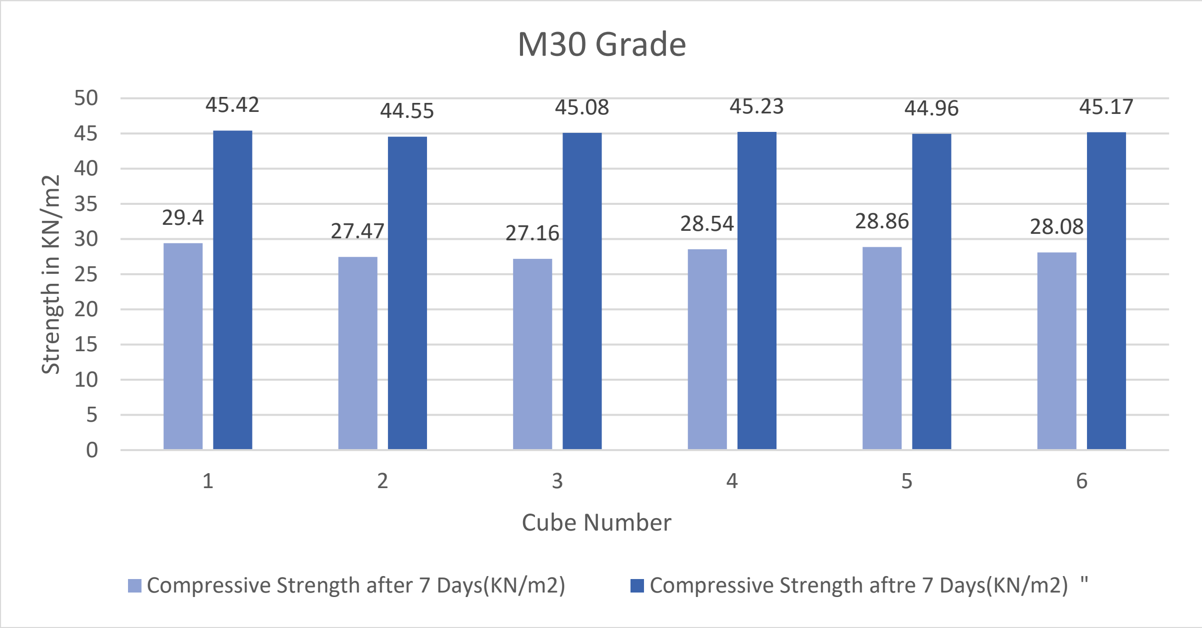
RESULTS AND CONCLUSION.

We have tested the compressive strength cubes for 7 days and 28 days. These recorded values of compressive strength were interpreted in Table 2.

Table 2: Compressive strength results after 7 days and 28 days

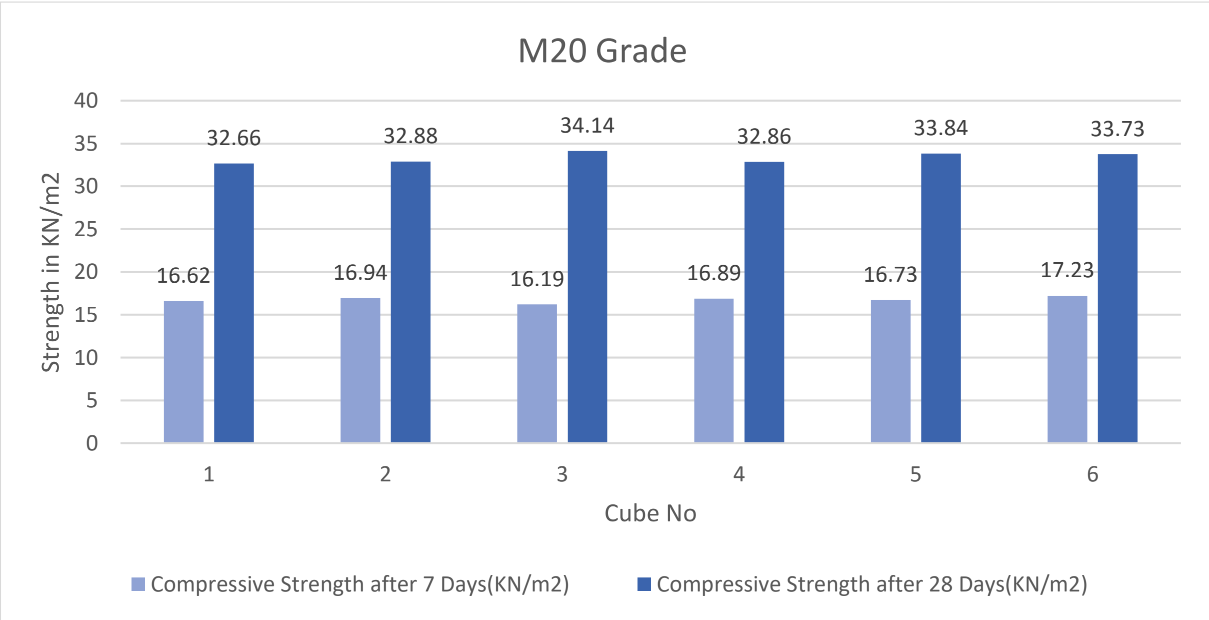
Sr No	**M30 Grade**		**M20 Grade**	
	7 days	**28 days**	**7 days**	**28 days**
	KN/m^2	KN/m^2	KN/m^2	KN/m^2
1	29.40	45.42	16.62	32.66
2	27.47	44.55	16.94	32.88
3	27.16	45.08	16.19	34.14
4	28.54	45.23	16.89	32.86
5	28.86	44.96	16.73	33.84
6	28.08	45.17	17.23	33.73
Avg	28.25	45.06	16.77	33.35

Fig 1 Bar chart showing compressive strength of M30 grade of concrete after 7 days and 28 days



- Compressive strength results of M30 grade concrete after 7 days and 28 days cubes found acceptable

Fig 2 Bar chart showing compressive strength of M20 grade of concrete after 7 days and 28 days



- Compressive strength of M20 grade concrete cube initially after 7 days is not satisfactory but after 28 days found acceptable.

Conclusion

Based on the results of the experimental investigations conducted, the following conclusions were made.

1. The concrete mixture made by addition of CONCARE B-14 with hard water do not affect the fresh properties such as slump, retention time etc.
2. The 28 days average Compressive strength obtained for M30 and M20 grade concrete using CONCARE B-14 with hard found satisfactory. So, we can use CONCARE B-14 with hard water which do not affect the durability properties of concrete.
3. From experimental analysis it can be said that, we can replace potable water by hard water using CONCARE B-14 as a neutralizing agent for M30 and M20 grade of concrete.
4. As potable water is not readily available on construction site hence by using hard water with CONCARE B-14 we can reduce cost of potable water.
5. By using CONCARE B-14 comprises of fly ash and sodium silicate which is an industrial waste gives us environmentally friendly output.

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