Study of the Effect of Curing with Fresh Water and Salt Water on Structural Strength of Concrete – A Review

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Abstract— The modern era is focusing on the taming, sustainability and recycling of the resources by imparting innovative techniques and methodologies. Keeping this in view, a study was conducted on the strength of concrete after preparing and curing with different types of water for structural use. This work deals with the study of various effects of preparing and curing with salt water on properties of strength of concrete such as compressive strength, tensile strength and flexural strength with respect to fresh water. This study indicated that the strength of concrete of the mixtures prepared using salt water was comparable with the strength of the control mixture. Also, the water absorption of concrete is not affected when salt water was used. The study also indicates that the initial and final setting time of cement was same as that of Potable water and Secondary Treated salt Water but decreased for Primary Treated salt Water, for compressive strength it was increased in Secondary Treated Waste Water and salt waste water at longer duration, for tensile and flexural strength tests was same results so, there was no any improvement in tensile and flexural strength by using Secondary Treated salt Water.

Keywords: High Strength Concrete, Fresh Water, Salt Water, Compressive Strength, Tensile Strength, Flexural Strength, Curing

I. INTRODUCTION

In early days, water was primarily used for domestic needs like drinking, washing, bathing and cooking etc. But due to modernization, water is also required for industrial, construction purpose, ornamental and sewerage purposes along with domestic needs. Also in construction industry water is used for mixing, aggregate washing, curing of concrete and for washing concrete related mechanical machines. The mixing of water which is fit for drinking purpose is fit for concreting, but about 97 percent of water is held in the oceans, while only 3 percent is fresh water. Of the freshwater, only 1 percent is easily accessible as ground or surface water, the remains are stored in glaciers and icecaps. Moreover, freshwater is not evenly distributed across land surfaces, and there are a number of heavily populated countries located in arid lands where fresh water is scarce. The ultimate and last option will be treating the salt water and using it. But the humans have not accepted or will never accept the treated salt water for drinking purpose. So this treated salt water can be in the construction industry where the large amount of water is used and the freshwater is used. This works deal with the study of effect of using treated salt water in construction industry which reduces the load on nature.

Concrete is the premier construction material and widely used in civil engineering work. Concrete is the product or mass made by the use of cementing medium. The main component of concrete is mixture of cement water and aggregate.

A. Advantages of Concrete:

- Concrete is economical as compared to other engineering material, except cement.
- Concrete possess high compressive strength, corrosive and weathering effect are minimum. When properly prepared strength is equal to that of natural hard stone.
- It is strong in compression and has unlimited structural application in combination with steel reinforcement, the concrete and steel had equal coefficient of thermal expansion.
- Concrete is durable and fire resistance and require very little maintenance.
- Concrete can even be sprayed on and filled into fine cracks for repairs by the guniting process.
- The concrete can be pumped and hence it can be laid in the difficult positions also.
- It is durable and fire resistance and requires very little maintenance.

B. Disadvantages of Concrete:

- Concrete has low tensile strength and hence cracks easily. Therefore it is to be reinforced with the steel bars or meshes
- Fresh concrete shrink on drying, and hardened concrete expands on wetting.
- Concrete under sustained loading undergoes creep resulting in reduction of prestress of the prestressed concrete construction.
- Concrete is liable to disintegrate by alkali and sulphate attack.
- The lack of ductility inherent in concrete is disadvantages with respect to earthquake resistance.

C. Curing of Concrete

Curing of concrete may be defined as the process of maintain the moisture and temperature condition of concrete by the hydration reaction to the normally so that concrete develop harden properties over time. The main components which need to be taken care are moisture, heat and time during the process.

Depending upon the site constraints, type of structure and other material parameters, different methods of curing are adopted at site. Methods of curing concrete fall into the following categories:

Water curing: Water curing prevents the water loss from the concrete surface by uninterrupted wetting of the exposed surface of concrete. It's done by spraying or sprinkling water or curing agents over the concrete surface to ensure that the concrete surface is continuously moist. Moisture from the body of concrete is retained from evaporating and contributes to the strength gain of concrete.

Water curing methods are:
1) Pounding
2) Sprinkling, fogging & mist curing
3) Wet covering

1) Salt Water:

Salt water, is water from a sea or ocean. On average, seawater in the world's oceans has a salinity of about 3.5% (35 g/l, 599 mm). This means that every kilogram (roughly one liter by volume) of seawater has approximately 35 grams(1.2 oz)of dissolvedsalts (predominantly sodium (Na^+) and chloride (Cl^-) ions). Average density at the surface is 1.025 kg/l. Seawater is denser than both fresh water and pure water (density 1.0 kg/l at 4 °C (39 °F)) because the dissolved salts increase the mass by a larger proportion than the volume. The freezing point of sea water decreases as salt concentration increases.

2) Salt Characteristics:

- Crystals or white crystalline powder.
- Transparent and colour less in crystalline form – rather like ice.
- Crystallises in the isometric system, usually in the form of cubes.
- Soluble in water (35.6g/100g at 0°C and 39.2g/100g at 100°).
- Slightly soluble in alcohol, but insoluble in concentrated hydrochloric acid.
- Melts at 801°C and begins to vaporize at temperatures just slightly above this boiling point 1,413°C.
- Hardness of 2.5 on the MOH scale of hardness.
- Specific gravity of 2.165.
- Non-combustible – low toxicity.
- Hygroscopic – absorbs moisture from damp atmospheres above 75 per cent relative humidity – below this, it will dry out.

  In its natural form, salt often includes traces of magnesium chloride, magnesium sulphate, magnesium bromide, and others. These impurities can tint the otherwise transparent crystals, yellow, red, blue or purple.

3) Chemical Property of Salt Water:-

When an electric current is passed through a strong solution of salt in water, electrolysis occurs and three products are formed:

- Chlorine (Cl_2)
- Sodium hydroxide (NaOH)
- Hydrogen (H_2).

Because hydrogen and chlorine gases form an explosive mixture, it is important to keep them separated. All three products are useful individually and they can also be combined together to make further products. Sodium hydroxide and chlorine combine to form sodium hypochlorite solution which is widely used in the home as domestic bleach. A stronger solution of sodium hypochlorite is used as a dairy and industrial disinfectant.

Under different reaction conditions, sodium hydroxide and chlorine will react to form sodium chlorate. This is produced as white crystals which can be highly explosive or inflammable if mixed with organic matter. Solutions of sodium chlorate are widely used as a herbicide.

When chlorine gas is burned in hydrogen, the two gases react to form hydrogen chloride. The hydrogen chloride dissolves in water to form hydrochloric acid. Hydrochloric acid made in this way is very pure, and can be used safely in the food and pharmaceutical industries.

II. LITERATURE REVIEW

A brief review of previous studies on the effect of using salt water on the strength of concrete has been enhanced here. This literature review also includes previous studies on treated salt water. This literature review on recent contribution related to effect of using waste water on the strength of concrete either by preparing with it or by curing with it. On the basis of survey of available literature following gaps in the research are being identified. There is very limited research which focuses on comparison of strength of concrete with curing by fresh water and salt water

A. Preeti Tiwar I (2014)

In this research work, the effect of salt water on the compressive strength of concrete was investigated. This paper therefore presents the result and findings of an experimental research on the effect of salt water on compressive strength of concrete. For this concrete cubes were cast using fresh water and salt water for a design mix of M-30 1:1.8:3.31 by weight of concrete, and 0.45 water-cement ratio. Half of concrete cubes were cast and cured with fresh water and remaining half cubes were cast and cured with salt water. The concrete cubes were cured for 7,14 and 28 days respectively. The result of the average compressive strength of concrete obtained using fresh water ranges from 27.12 - 39.12N/mm2 and using salt water ranges from 28.45

B. Mohammad Raihan Mukhlis (2017)

Coastal areas are getting populated day by day with lots of hotels and residential buildings considering the tourists attraction. But non availability of plain water for curing and seawater intrusion in coastal regions has a great impact on the strength of concrete structures in coastal regions. Again recycled aggregates of demolished concrete are being wasted without any beneficial use. These recycled aggregate can be reused in concrete construction in the coastal regions if it is possible to gain a rational percentage of strength after some specified curing periods. So to study the optimum percentage of recycled aggregate on recycled concrete in salt environment, three types of variables are used in this study. Percentage of recycled aggregate, curing period and concentration of saline water are those three variables involved. For this study 3 various percentage of recycled aggregate used in concrete casting which are 30%, 40% and 50% recycled aggregate. For the 3 different types of aggregate samples 3 different types of concrete has been cast in 100 mm cube specimen and cured in 3 different concentrations of 1N, 3N and 5N curing water. The specimens are then tested for compressive strength for curing periods of 28 days, 60 days and 90 days. The results of compressive strength test of these recycled concrete are then compared with the compressive strength of plain concrete with 0% recycled aggregate cured in plain water by

considering it as a standard. From the investigation work it has been found that concrete cast with 30% recycled aggregate achieves 95.4% compressive strength for 28 days curing in 1N concentration of saline water, which is comparatively higher among other recycled concrete used here. Percentage of strength achievement are higher for 28 days curing but it starts to decrease with the increase of curing period in saline water compared to the strength of concrete cured in plain water. Compressive strength decreases with increasing percentage of recycled aggregate and increasing concentration of salinity. Thus 30% can be said to be the optimum percentage of recycled aggregate in this study which is accessible to use in marine structures only.

C. Ibrahim Asiwaju-Bello,(2017)

The ceramic industry inevitably generates wastes, irrespective of the improvements introduced in manufacturing processes. This research examines the feasibility of using ceramic wastes in concrete and the effects of fresh and salt water environments on the compressive strength of the concrete. In this study the cement has been replaced with ceramic waste powder accordingly in the range of 0%,5%, 10%, 15%, 20%, and 30% by weight for concrete which was cured for 56 days in two liquid media (fresh and salt water).The findings revealed that use of waste ceramic enhances the properties of concrete cured both in fresh and salt water media, based on the results from the compressive test, higher compressive strength occurred in concrete cured in salt water than fresh water. The results demonstrate that the use of ceramic powder asactive replacement endows cement with positive characteristics like major mechanical strength and the economic advantages. The concrete also exhibited a high compressive strength in both water bodies. Reuse of this kind of waste has economic and environmental advantages (onshore and offshore structures). Indirectly, all the above contribute to a better quality of life for citizens, introduce the concept of sustainability and greenhouse in the construction sector.

D. J. A. O. Barros (2010)

Testing and modeling In this paper the results of tests performed on specimens and structural elements made of steel fiber reinforced concrete are presented. Fiber content ranged from 0 to 60 kg/m3 of concrete. Using the results of the uniaxial compression tests performed under displacement Control condition. Reinforced Concrete Cross Sections was developed. The model performance and the benefits of fiber reinforcement on thin slabs reinforced with steel bars were assessed by carrying out tests on slab strips. The main results are presented and discussed structural concrete, fiber reinforcement, fracture energy, constitutive relations, experimental tests, flexural model.

E. K.S. Al-Jabri (2011) Science Direct

This paper investigates the effect of using wastewater on the concrete of high strength concrete. Wastewater samples were collected from three car washing stations in muscat area, high strength concrete mixture were prepared using different proportion of wastewater and water to cement ratio of 0.35. The percentage of wastewater replaced ranged between 25-100% of tap water used in concrete. Slump compressive, tensile and flexural strength were determined 28days of curing. Cube compressive strength was also determined at 7 days of curing. Results indicated that the strength of concrete of the mixture prepared using wastewater was comparable with the strength of the control mixture. Also the water absorption of concrete is not affected when wastewater was used.

F. Rakesh A. More(2014)

The study centered on the effect of different qualities of water on concrete compressive Strength. The concrete mix of M20 grade with water cement ratio of 0.5. Were investigated. S Water samples, such as tap water, waste water, well water, bore well water & mineral water (packed drinking water) were collected from various sources at college campus and were used to cast 150mm concrete cubes. The cured cubes were crushed on 7 & 28 days for compressive strength estimation. The results showed that the compressive strength of the concrete cubes made with mineral water, tap water, well water, waste water increased with days & not having much variation in their compressive strength.

G. P. Rama Mohan Rao(2014)

This paper focus on the usage of treated waste water in the production of concrete so that the shortage and cost using potable water can be greatly reduced. In this paper, it t is chosen treated waste water, which give us the exact idea of corrosion and for the construction as well as strength and durability properties of the concrete. To determine the mechanical properties of concrete cast cube specimens using M 20 grade concrete with potable and treated waste water. Water absorption test in order to determine the difference in absorption capacity. The other tests, which are conducted include Rapid Chloride Penetration Test (RCPT), sulphate and chloride test are conducted on potable as well as treated waste water at 7, 14 and 28 days. Concrete cast with treated waste water attained more compressive strength when compared with concrete cast with potable water and the chloride permeability is high for treated waste water concrete compared to potable water concrete.

H. Akinwumi, I.I(2014)

This paper presents the results of an experimental study on the effects of curing methods and curing ages on the compressive strength development of ordinary Portland cement concrete in a tropical environment. Fifteen (15) concrete cubes each were cured by immersion in potable water, immersion in lime water, covering with wet rug, covering with plastic sheets and air-drying. For each of these curing methods, the average compressive strength of concrete cubes was determined after 3, 7, 14, 28 and 90 days curing periods. The results obtained discourages the use of curing by air-drying method and also suggests limiting the use of the other curing methods to 28-days period. Generally, the highest compressive strength was obtained for concrete cured by immersion in lime water.

I. Kouslov Sorkor, Todesse M(2014)

The scarcity of freshwater in densely populated urban centre's has necessitated conservative utilization of depleting water resources. The prospect of using reclaimed wastewater for concreting operations in lieu of the conventionally topped municipal, surface and ground water sources bears o greol potential in this regard. The present study compares the influence of four different surface curing , viz. (i) trebled wastewater, (ii) top water and commercially violable (iii) water bossed and (iv) resin bossed curing compounds on the compressive strength and water absorption characteristics of ordinary concrete. The observations establish the suitability of waste water curing in achieving better strength and water tightness of 28 days. Keywords: Concrete; curing

J. Shehdeh Mohammad Ghannam (2016)

The aim of this study is to find a solution for the large volume of sludge produced in the wastewater treatment plant in Jordan in order to decrease the environmental pollution in the air, as well as to assess the strength of sludge concrete using treated water in concrete mix as a comparison with the strength of sludge concrete made by the tap water. Compressive strength of sludge concrete for treated water was compared with the strength of sludge concrete made by tap water. The results show that using sludge concrete mixes decrease the strength of cube about (9.3%) when water was used.

K. A. Olonade(2016)

This paper reviews the degradation mechanism of wastewater on reinforced concrete structures with a view to finding what needs to be done to salvage these structures. Potential disintegrating agents in wastewater generated in Nigeria were identified and common degradation effects were examined. Regeneration, preventive and corrective techniques were noted. While noting that poor maintenance culture, lack of multidisciplinary research work and high cost of maintenance were major factors responsible for the high rate of deterioration. The paper, therefore, concluded with suggestions that could be employed to salvage these structures from total collapse. One of such approaches is to use admixtures, which could reduce the effect of acidic attack common in wastewater concrete structures. Influence of grey water on physical and mechanical properties of mortar and concrete mixes Influence of grey water on physical and mechanical properties of mortar and concrete mixes

L. Ayoup M. Ghrair etal (2016)

This project aims to evaluate the potential of reused grey water in concrete and mortar in order to preserve fresh water for drinking purposes. Using both Treated Grey Water and Raw Grey Water (TGW and RGW, respectively) led to a significant increase in the initial setting time and a decrease in the concrete slump value. In addition, there was no effect on mortar soundness properties. The mortar and concrete compressive strength results obtained at 7 days moist curing time showed a significant increase. Mortar and concrete mixes using TGW cast at curing times of 28, 120, and 200 days led to no significant effects on compressive strength. On the contrary, the RGW achieved slightly negative impact on compressive strength at all curing ages. According to the American Society for Testing and Materials (ASTM C109), TGW and RGW are suitable for mortar and concrete production. Furthermore, these results are in harmony with established requirements for ASTM C94.

M. Miss. Kirtimala Laxma Narkhede (2017)

She investigated durability impact of concrete by using recycled waste water. They used the recycled waste water from the tannery industry for the construction purpose, so that the shortage in water can be greatly reduced by making some primary treatment. Then the specimens were also casted by adding the concrete admixture with dosages of 0.5%, 1.0%, 1.5%, 2.0% and 2.5%. The specimens were tested for durability properties for 28 days, 90 days and 365 days. By using this cubes and cylinders were casted and tested for its durability.

N. Lei Chen,(2017)

In the research, the effects of sea water for mixing, curing on the gain in strength of different grades of concrete was investigated. A total of 192 concrete cubes were tested for their compressive strength. The study shows that sea water affects the rate of gain in strength of concrete when used for mixing or curing. The strength of concrete made by using sea water was observed to be decreased by about 15% as compared to the similar concrete specimens made and cured with fresh water at 90 days. The concrete with higher strength showed poorer resistance against strength deterioration as compared to the lower strength concrete which used sea water for curing. And the concrete made with sea water decreased the stability of concrete properties.

III. CONCLUSION

In the construction industry fresh water is used .but many part of world faces serious deficit in fresh water .the increase in the economic activities as well as the population grow caused a substantial increase in water demand. As the freshwater is becoming scarce it is important to reduce freshwater consumption in construction industry so it is essential to evaluate the behavior of concrete while using salt water. This study also gives an idea to evaluate the compressive strength, tensile strength and flexural strength of concrete by curing with salt water. During the construction, curing of concrete by proper use of water makes concrete more stronger more impermeable and more resistant to stress, abrasion and freezing and thawing.

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