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UTILIZATION OF SEA WATER FOR CONSTRUCTION, AS AN ALTERNATIVE FOR POTABLE WATER

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Abstract:
One of the mostly used materials for construction purpose presently is concrete and the reason behind its use is its good compressive strength and durability. The consumption of concrete in the world is estimated to be around 12 billion tons every year. The strength and durability of concrete will be fully developed only if it is cured. Curing of concrete structure is essential if it is to perform the intended function over the design life of the structure. Concrete is needed to be provided with moisture for a minimum period of 28 days for good hydration and to attain desired strength. Any laxity in curing will badly affect the strength and durability of concrete. An area like sea side, or the area where saline water is available for the curing, is a scarcity of pure water where curing with normal water is difficult and in cases where large areas like pavements have to be cured.
In this paper, we study the different tests analyzing the effects of mixing and curing concrete with saline seawater on the compressive, tensile, flexural and bond strengths of concrete. For testing, three group of cube casted in the laboratory, in which six cubes of concrete mixes were mixed and cured in fresh water, six cubes were mixed and cured in seawater, while four cubes were mixed with fresh water and cured in seawater. These cubes were cured for 7, 14, 21, 28 days and were tested for compressive strength. For this concrete cubes were cast for a design mix of M-20, 1:1.777:2.826 by weight and 0.45 water cement ratio.

Keywords: Curing, Durability, Strength, Salt, Concrete, Sea water, Compressive Strength

INTRODUCTION

In modern day construction, Concrete is one of the major building materials used. The reason behind its use in large quantities is due to its excellent structural performance and durability. It is used for numerous purposes in construction such as construction of buildings, dams, foundations, highways, parking structures, pipes, and poles [1]. Also, the use of concrete offshore drilling platforms and oil storage tanks is already on the increase. Concrete piers, decks, break-water, and retaining walls are widely used in the construction of harbors and docks. Floating offshore platforms made of concrete are also being considered for location of airports, power plants, and waste disposal facilities in order to relieve land from pressures of urban congestion and pollution [2]. It is very tough to find an option for concrete in construction, which is durable and economic. The durability of concrete is generally regarded as its ability to resist the effects and influences of the environment, while performing its desired function [3]. Concrete is a composite material composed mainly of water, aggregate, and cement. Water is an important ingredient of concrete as it actively participates in chemical reaction with cement [4]. Proper curing of concrete structures is important to meet performance and durability requirements. In conventional curing this is achieved by external curing applied after mixing, placing and finishing [5].
One of the greatest problem the world is facing is the rapid increase in population. As per the Researchers in the near future, fresh water will be scare and very difficult to get. It is said that in 2025 half of the mankind will live in the areas where fresh water is not enough [4]. Curing of concrete stands for procedures devoted to promote cement hydration, consisting of control of time and humidity conditions immediately after the placement of concrete mixture in to form work. Curing is designed primarily to keep the concrete moist, by preventing the loss of moisture from the concrete during the period in which it is gaining strength. The amount of mixing water in concrete at the time of placement is normally more than must be retained for curing. However excessive loss of water by evaporation may reduce the amount of retained water below that necessary for development of desired properties [6]. Curing is carried out by supplying water to the surface of concrete in a way that ensures that it is kept continuously moist. The water used for this purpose should not be more than about 5°C cooler than the concrete Surface [6].
During summer season, when the temperature is high, the curing of pavement and slabs done by the help of a pond or immersion. But there is big problem of having sufficient pure water for the curing, in sea areas. So, there is a need to explore alternative for potable water in construction industry as billions of water is used for mixing and curing of concrete. Oceans

make up 71 percent of the surface of the earth; therefore, a large number of structures are exposed to seawater either directly or indirectly [4].
Thus, the usage of sea water is an alternative in construction for mixing or at least for the curing. In this paper, Concrete grades of M-30 design mix with a slump in between 75 to 100 mm were considered.

Need for Investigation of the Usage of Sea Water:
As per the researchers the world will face a scarce condition for drinking water because of it's over exploitation, hence fresh water will also not be available for concreting purpose. We use bore water for mixing as well as curing of concrete instead of fresh water. But concreting required many billions of water for mixing and curing in the whole world. To fulfill this requirement of water, the study is done on the use of sea water instead of fresh or bore water and the effect of sea water as mixing and curing on concrete. An investigation recently carried out by Portland Cement Association (PCA) on long time study of cement performance in concrete (LTS) program provides key insights into the performance of concrete in seawater [7]. Therefore the selection of materials, mix design, and proper detailing of reinforcement are also essential parameters in producing a durable concrete structure for saline water [8].
Seawater is the water obtained from sea. Its taste is salty. Sea water can be said to have a solution containing a great number of elements in different proportions. The primary chemical constituents of seawater are the ions of chloride, sodium, magnesium, calcium and potassium. In seawater containing up to 35,000 ppm of dissolved salts, sodium chloride (NaCl) is by far the predominant salt (about 88% by weight of salts) [9]. The pH value of seawater varies between 7.4 and 8.4. Seawater is an adequate electrolytic and plays a major function in any electrolytic action between dissimilar metals and between salt concentration and steel [10].

LITERATURE REVIEW

Akinkurolere O.O et.al said sea water is a complex solution of many salts containing living matter, suspended silt, dissolved gases and decaying organic material. The average salt concentration of sea water is about 3.5% depending upon its location. The primary chemical constituents of seawater are the ions of chloride, sodium, magnesium, calcium and potassium. The concentration of major salt constituents of seawater we are given in weight % of salt as 78%NaCl, 10.5% MgCl2, 5% MgsSO4, 3.9% CaSO4, 2.3% K2SO4 and 0.3% KBr [11].
A number of studies have shown the effects of the mixing and curing of seawater on the compressive strength of cement–sand mortars and corresponding concrete. Many researchers investigate the effects of sea water on the mixing and curing of structure.
Falah M. Wegian investigated the effects of mixing and curing concrete with sea water on the compressive, tensile, flexural and bond strengths and reported that there are increases of strengths of concrete mixed and cured in sea water at early ages and a definite decrease for ages more than 28 days and up to 90 days [12]. Naghoj and Abdel-Rahmna (2005) reported that adding loam to a concrete mix can increase the compressive strength of the concrete under normal conditions and enhance the performance of hardened concrete to resist the aggressive mediums of salty seawater [13].
Recent studies showed that the use of sea water in mixing and curing will not harmful for the structures.
P. Krishnam Raju et.al concluded that there is no reduction in compressive strength due to mixing and curing of sea water, whereas the average compressive strength arrived for designated concretes are more than the target strength [14]. **Nobuaki Otsuki et.al** concluded from the test results and discussions and are confident to safely use sea water as mixing water [15]. **O.O. Akinkurolere et.al** concluded that concrete cast with sea water and cured with sea water increases the 28 days compressive strength dramatically and linearly beyond that obtained when cast in fresh water and cured in fresh water [11]. **Preeti Tiwari et.al** performed series of experiments on M-30 grade and said that there is marginal increase in the strength of cubes cast and cured in salt water as compared to those of cast and cured in fresh water at all ages of curing and concluded that there is no reduction in the strength if we use salt water casting and curing the concrete [16].
Further investigation is recommended on this subject of using seawater for concrete mixes, as the planet earth is experiencing noticeable shortage of pure clean water sources for future construction work, and the use of seawater to develop durable concrete of lasting performance will be greatly beneficial.

MATERIALS

The detail of various required materials for the testing are following:-

a) **Cement-:** OPC 43 grade (ACC cement) was used.

b) **Coarse Aggregate:** Crushed granite stone aggregate of maximum size 20mm confirming to IS 383-1970 was used. The specific gravity were found to be 2.78 for 20mm size of particle and 2.76 for 10mm size of particle and fineness modulus is found to be 7.25 for 20mm size of particle and 6.68 for 10mm size of particle.

c) **Fine Aggregate:** The fine aggregate used in this investigation was Kosi River sand passing through 4.75 mm sieve with specific gravity of 2.83.

d) **Salt water:** Seawater 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). The cubes were prepared using 35g of salts in one liter of water.

e) **Fresh Water:** Ordinary clean portable water free from suspended particles and chemical substances was used for both mixing and curing of concrete cubes cast with fresh water.

The fresh water used was gotten from the tap at the Civil Engineering Department Laboratory, Mohammad Ali Jauhar University, Rampur, UP and the sea water prepared as per the sample of the water of Trivandrum beach Kerala, India.

METHODOLOGY

Experimental Procedure:

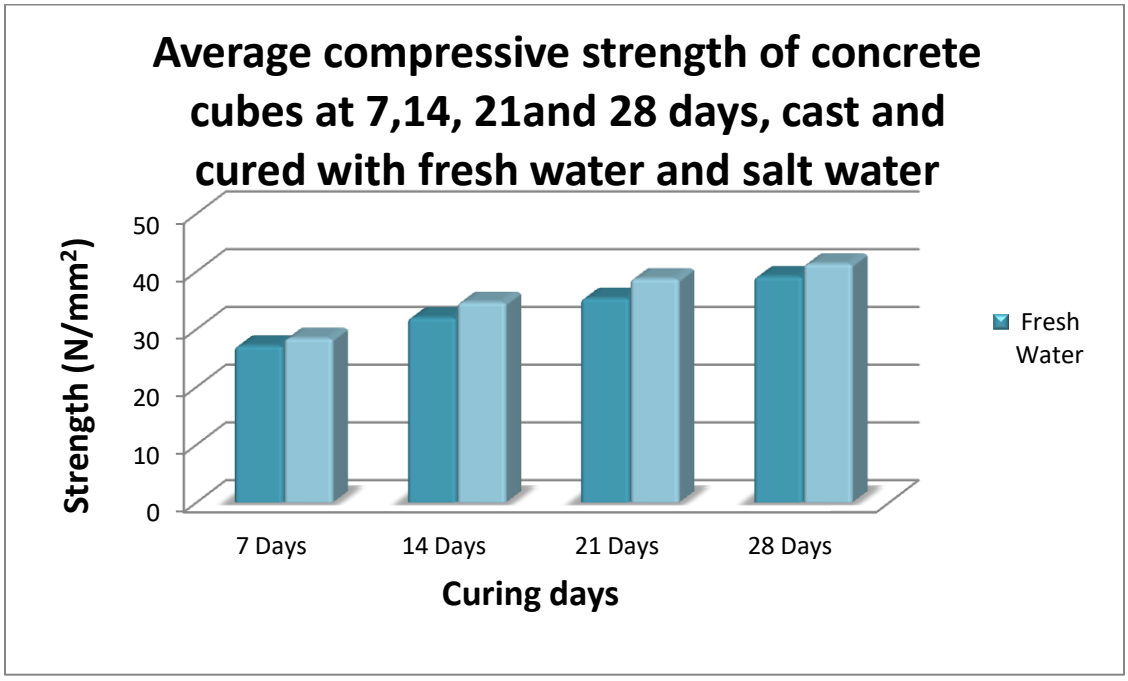
To study the various effects of sea water on different properties of concrete, half of the concrete cubes were cast and cured with potable water and half of the concrete cubes were cast and cured with sea water. The amount of salt (NaCl) used in water was kept as 35g/liter).

The size of cube measuring **150×150×150** mm in dimension was used. The batching of the concrete was carried out by weight. Mixture was proportioned for target strength of 30N/mm^2 and had a cementitious material content of 372kg/m3, a fine aggregate content of 669.68kg/m3, a coarse aggregate content of 1230.6kg/m3 and a water cement ratio of 0.45. The concrete was properly mixed using the sea water and potable water respectively, the concrete cubes mould were filled in three layers in which each of the layer were compacted 25 times respectively. The concrete cubes were cast and cured for 7, 14, 21and 28 days respectively and was tested for compressive strength.

Testing Results

After casting and de-moulding, it is concluded that the salt water concrete cubes has a darker surface than the reference concrete cubes, when cured in salt water a deposit of salt formed on a specimens with whitish appearance at bottom edges. The compressive strength test was performed on the concrete cubes, tested at the curing age of 7, 14, 21, and 28 days using the compression testing machine. Test results of the cubes prepared from fresh water and water containing salts. Results indicate that, there is increase in the compressive strength of concrete of all concrete cubes.

The average compressive strength of concrete cubes at 7,14, 21and 28 days, cast and cured with fresh water and salt water, as shown in graph 1.



Graph 1: Average compressive strength of concrete cubes.

Conclusions

From the final results it is to be concluded that, there was a gradual increase in the concrete cubes which were casted and cured with salt water as compared with the concrete cubes casted and cured with fresh water. The rate of the strength gain in fresh water cubes is slow as compared with the salt water cubes. The strength of concrete batches cast with salt water and

cured with fresh water was also observed to have increased even at 28 days. Although, the compressive strength of the salt water concrete cubes was slightly higher than that of the fresh water concrete cubes.

Based on the result, the following conclusions may be list out:

1) The specimens mixed and cured in seawater have higher compressive, tensile, flexural and bond strengths than concretes mixed and cured in potable or fresh water in the early ages at 7 and 14 days. The strength increases by 4-6% at 7 days and 9-11% at 14 days.
2) It is seen that there is no remarkable reduction in compressive strength due to mixing of sea water and also mixing and curing of concrete with sea water compared to characteristic target strength. The strength decreases by about 1-4% at 28 days.
3) The average characteristic compressive strength obtained for concrete cubes using potable water and sea water was 33.4 N/mm^2 35.80 N/mm^2 respectively for M-30 grade of concrete.

After getting the results from the different test performed on the concrete mixtures using sea water and drinking water we can conclude that there is no remarkable variation in the compressive strength if sea water is used for casting and curing the concrete. In practice, the fresh water situations occur in building constructed on inter lands and main lands. The fresh-salt water situations are mainly in structures or building close to lagoon or sea. The salt-fresh water situations are very rare in practice, but are well pronounced in areas where there is scarcity of fresh water or the available surface water is salty. The salt water situations are visible mostly in structures built in ocean or sea [7].

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