Effect of Saline Water in Mixing and Curing on Strength of Concrete

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Abstract*- Presently, concrete is most widely used construction material due to its good compressive strength and durability. It is estimated that the consumption of concrete in the world is 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, The effects of sodium chloride (NaCl) solutions as mixing and curing at concentrations of 1g/l, 2g/l, 4g/l, 6g/l and 8g/l .A total of 72 concrete cubes, using metal mould of 150 X 150 X 150mm size, were cast with, chemicals and fresh water. 12 cubes of concrete were mixed and cured in fresh water. 60cubes were mixed and cured in sodium chloride.

The compressive strength of the cubes determined through crushing at 7, 28 and 48 days respectively.

These cubes were cured for 7, 28 and48 days and were tested for compressive strength respectively. For this concrete cubes were cast for a design mix of M-30, 1: 1.46: 2.64 by weight and 0.42 water cement ratio.

Keywords- Curing, Durability, Strength, Salt, Concrete, Saline water, Compressive Strength

I. INTRODUCTION

Concrete is one of the major building materials use in modern day construction. Concrete is used in large quantities due to its excellent structural performance and durability. Concrete 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].

Due to rapid growth of population the world is facing a number of problems. Researchers say on 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].

When the ambient temperature is sufficiently well above freezing, the curing of pavements and slabs can be accomplished by ponding or immersion [6]. 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 billons 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 Saline 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.

II. NEED FOR INVESTIGATION OF THE USAGE OF SALINE WATER

Many researchers warns that, in near future there will be shortage of drinking water itself, 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 billion of water for mixing and curing in the whole world. To fulfill this requirement of water, the study is done on the use of Saline water instead of fresh or bore water and the effect of Saline 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 water of sea or oceans, which is salty in taste. 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].

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.

III. MATERIALS

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

Cement-:PPC (ACC cement) was used.

Coarse Aggregate: Crushed granite stone aggregate of maximum size 20mm confirming to IS 383-1970 was used. The specific gravity were found to be 2.72 for 20mm size of particle and 2.70 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.

Fine Aggregate: The fine aggregate used in this investigation those sand which passing through 4.75 mm sieve with specific gravity of 2.65. The grading zone of fine aggregate was zone IInd as per Indian standard specification.

Saline water: moderate saline water is used. This means that every kilogram (roughly one liter by volume) of saline water has approximately 10 grams of dissolved salts (**Sodium** (Na^+) and **Chloride** (Cl^-) ions). The cubes were prepared using 10g of salts in one liter of water.

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, Integral University, Lucknow, UP.

IV. METHODOLOGY

A. Experimental Procedure:

To investigate the effect of Saline water on compressive strength 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 Saline water. The amount of salt (NaCl) used in water was kept as 8g/liter).

The size of cube measuring **150×150×150** mm^3 in dimension was used. The batching of the concrete was carried out by weight. Mixture was proportioned for target strength of 38.25N/$mm^2$and a water cement ratio of 0.42. The concrete was properly mixed using the Saline 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, 28and 48 days respectively and was tested for compressive strength.

B. Specimen Preparation and Casting of Concrete Cubes:

The tests was carried out on concrete mixed cured in fresh water and seawater in order to determine the effect of the curing conditions for determining concrete strengths, namely, compressive strength, tensile strength, flexural strength and bond strength. Batching was done by weighing the materials for the concrete specimen using a Manual Weighing Balance. Concrete mix ratio of 1:1.46:2.64 by weight of concrete 0.42 water-cement ratio were used. Mixing was done by machine and the materials were thoroughly mixed in the dry state twice, after which water was added gradually while thoroughly mixing the concrete. Mixing of the concrete specimen continued by turning the mixture of cement, water and aggregates until the concrete was uniform in color and consistency. The mould wassmear with oil from inside so as to enhance easy removal of the set concrete. The fresh concrete mix for each batch was fully compacted by tamping rods, to remove trapped air, which can reduce the strength of the concrete. Workability of concrete which were made with fresh water and salt water separately, checked in time of casting of concrete cubes. The slump was maintained from 75 to 100mm i.e. for mass concrete.

72 concrete cubes were cast and cured in two batches. 12 cubes were made using fresh water, 60cubes were made using Saline water for 7,28 and 48. The cubes are de-moulded after 24 hour of casting, and cured in water having similar quality as used in the preparation of mix.

V. TESTING RESULTS

After casting and de-moulding, 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, 28, and 48 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.

Table 1,2and 3 shows the results of the average compressive strength of mortar cubes produced using fresh water and salt water.

Table 1: Results of 7days cube compressive strength

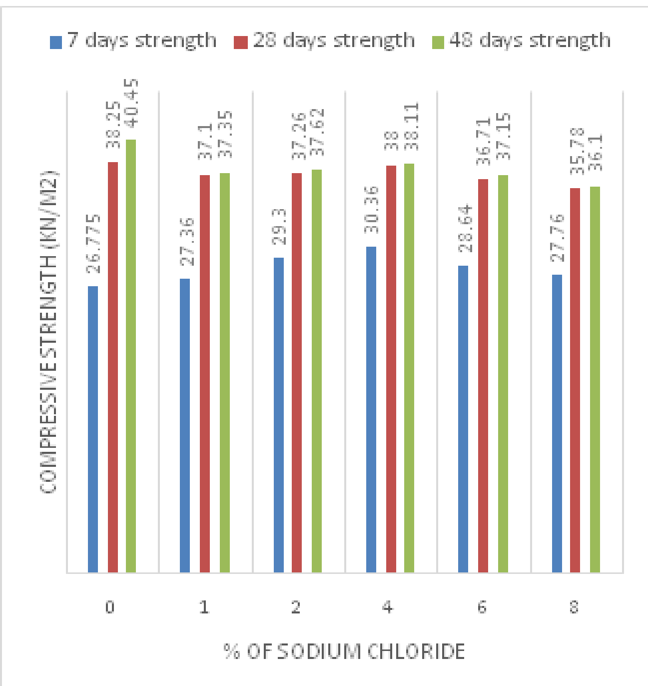
Grade of concrete	% of NACL used	Load (kN)	Avg. Comp. strength (N/mm^2)
M30	0 %	612	26.775
	1%	622	27.36
	2%	665	29.30
	4%	690	30.36
	6%	656	28.64
	8%	635	27.76

Table 2: Results of 28days cube compressive strength

Grade of concrete	% of NACL used	Load (kN)	Avg. Comp. strength (N/mm^2)
M30	0 %	845	38.25
	1%	842	37.10
	2%	845	37.26
	4%	860	38.00
	6%	834	36.71
	8%	810	35.78

Table 3: Results of 48days cube compressive strength

Grade of concrete	% of NACL used	Load (kN)	Avg. Comp. strength (N/mm^2)
M30	0 %	858	40.45
	1%	857	37.35
	2%	854	37.62
	4%	868	38.11
	6%	852	37.15
	8%	820	36.10



VI. CONCLUSIONS

From the results it is clear that, there was an gradual increase in the of 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 and cured with saline water was observed to have increased till 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) Experiments were conducted on M-30 grade of concrete. From the results it can be said that, there was an increase in the of compressive strength concrete cubes at early ages which were cast and cured with saline water at different concentration(1g/l, 2g/l, 4g/l, 6g/l and 8g/l) as compared with the concrete cubes cast and cured with tap water. The strength increase at 7 days and decrease at 28 days and 48 days .we used 1, 2 and 4g/l NACL in water then compressive strength increase at 6 and 8g/l NACL in water compressive strength decrease as compare to tap water.
2) There is no remarkable reduction in compressive strength due to mixing of saline water and also mixing and curing of concrete with saline water compared to characteristic target strength. The strength decreases by about 1-6% at 28 days.
3) 3)The average characteristic compressive strength obtained for concrete cubes using tap water and saline water was 40.45 N/mm^2 36.10 N/mm^2 respectively for M-30 grade of concrete.
4) From the above finding we can conclude that there is no remarkable variation in the compressive strength if saline water is used for casting and curing the concrete. This concrete can be safely used for mass concreting without any alteration in strength properties.

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