STUDY ON EFFECT OF SEA WATER FOR MIXING AND CURING ON STRUCTURAL CONCRETE

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ABSTRACT

Construction Engineering in Coastal areas are facing the challenge of shortage of fresh water for mixing and curing. The quality of water places an important role in the setting and strength development of Concrete structures. At least sea water can be adopted in the construction industry as an alternative ingredient to portable water particularly in the Coastal region. With the help of more Cement Matrix we can increase the workability of concrete because sea water affects the rate of gain in strength of concrete when it is used for mixing and curing.

In this research work, we check the effect of sea water performance compared to fresh water on the concrete is going to be investigated. Concrete mixes were prepared by varying coarse aggregates, cement proportions and types. In this we are using totally 12 specimens (4 Cubes, 4 Cylinders, 4 Beams) were casted and cured with fresh water and other 12 specimens (4 Cubes, 4 Cylinders ,4 Beams) were casted and cured using sea water. The Concrete cubes were going to be cured for 7, 14, and 28 days.

In this project we are going to present the results of an experiments on the effect of sea water performance compared to fresh water on Compressive strength, Flexural strength, Tensile strength, and Bond strength of concrete.

Keywords: (Sea water, Curing, Cement Matrix, Compressive Strength, Flexural Strength, Tensile Strength)

1. INTRODUCTION

Concrete has an excellent structural performance and durability, but is affected by early deterioration when subjected to a Marine environment. The most common cause of deterioration is corrosion of the steel reinforcement, with subsequent sapling of concrete. Therefore, the selection of materials, mix design, and proper detailing of reinforcement are essential parameters in producing a durable marine structure concrete. Moreover, if the utilization of saltwater as a solid material is allowed, it'll be very advantageous and conservative within the development, significantly within the sea coast. But the utilization of seawater isn't allowed because of the danger of early consumption of support, actuated by NaCl in seawater mixes. The quality of the water plays an important role in the preparation of concrete.

The primary chemical constituents of sea water are the ions of Chloride, Sodium, Magnesium, Calcium and Potassium. The concentrations of major salt constituents of seawater we are given in weight % of salt as 78% NaCl, 10.5%MgCl, 5% $MgSO_4$, and 3.9% $CaSO_4$, 2.3% K_2SO_4, and 0.3% KBr. On average sea water having total salinity about 3.5% per litre of sea water. Water containing massive quantities of chlorides. In Sea water containing up to 35,000 ppm of dissolved salts, sodium chloride (NaCl) is by far the predominant salt (about 88% by weight of salts. The pH value of seawater varies between 7.5 and 8.4). Corrosion of reinforcing steel occurs below pH of 11. Therefore, in case where concrete is subjected to a highly severe environment, the cement must supply alkalinity.

The chemical reactions of seawater on concrete are mainly due to the attack by Magnesium Sulphate ($MgSO_4$). Potassium and Magnesium Sulphates (K_2SO_4 and $MgSO_4$) present in salt water can cause sulphate attack on concrete because they can initially react with calcium hydroxide ($Ca(OH)_2$), which is present cement formed by the hydration of Dicalcium Silicate (C_2S) and Tricalcium Silicate (C_3S). The attack of Magnesium Sulphate ($MgSO_4$) is particularly damaging, forming soluble Magnesium Hydroxide (Mg $(OH)_2$), which forces the reaction to form gypsum. The most damaging effect of seawater on concrete structures arises from the action of chlorides on the steel reinforcement and the build-up of salts. These Chloride ions can penetrate into the concrete and cause accelerated corrosion of the reinforcement.

2. EXPERMENTAL

2.1 MATERIALS USED:

The different materials used in this investigation are as follows

- Cement
- Fine Aggregates
- Coarse Aggregates
- Fresh Water
- Sea Water

2.1.1 CEMENT:

In this project, we used ordinary Portland cement of grade 53 conforming to IS:12269-1987. The cement was obtained from a single consignment and of same grade and same source. It was stored properly until the completion of the project. The properties of cement are given in the following table

S.no	Properties	Fresh water	Sea water	IS: 12269-1987
1.	Specific Gravity	3.15	3.15	-
2.	Consistency	32%	32%	-
3.	Fineness	1.33	1.33	-
4.	Initial setting time	42 min	50 min	Min 30 min
5.	Final setting time	315 min	465 min	Max 600 min

Table:1 - Properties of Ordinary Portland Cement

2.1.2 FINE AGGREGATE (SAND):

The fine aggregate used in this project was manufactured sand. As per Indian standard specifications conforming to Zone- ii of Table 4 of IS:383-1970 sand was used. The standard sand shall be of quartz, light grey or whitish variety and shall be free from silt. The sand grains shall be angular, the shape of the grains approximately to the spherical from elongated and flattened grains being present only in very small or negligible quantities. The properties of fine aggregates are given in the following table.

S.no	Properties	Results
1.	Colour	Greyish White
2.	Shape of grains	Sub angular
3.	Specific Gravity	2.64
4.	Water Absorption	0.80%
5.	Fineness Modulus	3.8
6.	Bulk Density	1753

Table:2 - Properties of Fine aggregates

2.1.3 COARSE AGGREGATE:

According to IS:383-1970, coarse aggregate may be described as crushed gravel (or) stone when it results crushing of gravel (or) hard stone. The coarse aggregate procured from quarry was sieved through the sieved of sizes 20mm and 10mm respectively. In this project we use 60% of aggregates passing through 20mm and 40% of aggregates which are retained on 12mm sieve are used. The properties of coarse aggregates are given in the following table.

S.no	Properties	Results
1.	Colour	Greyish White
2.	Shape of grains	Angular
3.	Specific Gravity	2.72
4.	Water Absorption	0.99%
5.	Fineness Modules	6.68
6.	Bulk Density	1741

Table:3 - Properties of Coarse aggregates

2.1.4 FRESH WATER:

Normal ordinary clean portable water free from all suspended particles and chemical substances from laboratory was used for both mixing and curing of conventional concrete cubes casted with fresh water. The pH value of the fresh water should not be less than 6

2.1.5 SEA WATER:

Sea water is the water from a sea (or) ocean. On average, seawater in the world's oceans has a salinity of about 3.5%. This means that every kilogram of seawater has approximately 35 grams of dissolved salts. In this project, the seawater is used for both mixing and curing of conventional concrete cubes. The properties of sea water are given in the following table.

S.no	Properties	Results
1.	Ph	11.96
2.	Total Hardness	190ppm

3. RESULTS AND DISCUSSION

3.1 SETTING TIME OF CONCRETE:

Initial and final setting time of OPC/Fresh water & OPC/Sea water:

Type of water	Initial setting time (in mm)	Final setting time (in mm)
Fresh water	42 min	315 min
Sea water	50 min	465 min

Table:4- Setting time of concrete

3.2 WATER ABSORPTION:

Water absorption of concrete cubes with normal fresh water curing and sea water curing at 7, 14 & 28 days respectively. The results show that the water absorption is increased when it's compared to sea water.

3.3 WORKABILITY RESULTS:

Results obtained from slump cone test showing that the workability of concrete is various with the treatment of sea water instead of fresh water. From the slump cone results it's clear that with the increasing percentage of salinity leads to the increase the workability of concrete. Therefore, the workability is more for sea water then compared to fresh water.

Type of water	Slump values (in mm)	Compaction factor
Fresh water	100	0.92
Sea water	135	0.95

Table:5 - Compaction factor and Slump values for M25 grade concrete

3.4 COMPRESSIVE BEHAVIOUR:

The 28 days strength of the both concrete cubes which were made with sea water as well the as fresh water were evaluated. The compressive strength of the cubes which were made with sea water is observed to be lower than that of concrete cubes with fresh water. The strength reduction observed in concrete cubes with sea water when the salinity or salt content is increased the strength and workability is initially increases but does not continue through a long time. Due to salinity corrosion occurs in the reinforcement which reduces the strength as well as the durability of the concrete. After the curing of different age of concrete cubes were observed that the compressive strength will decrease in case of sea water.

In general, the compressive strength of concrete is decreased in sea water curing when its compare to normal water curing, reduction in strength of about 12% by volume. This reduction in sea water is due to porous in concrete which allows salts to penetrate into it and finally leads to loss of strength in concrete**.** The following tables shows the variation of compressive strength for 7,14,28 days after curing with fresh and sea water are as follows:

Cube Size(mm)	Age of Concrete(days)	Average compressive strength(N/mm^2)
150*150*150	7	26.78
150*150*150	14	35.97
150*150*150	28	47.55

Table:6 - Compressive strength of Concrete cubes Cast and Cured with Fresh water

Cube Size(mm)	Age of Concrete(days)	Average compressive strength(N/mm^2)
150*150*150	7	23.08
150*150*150	14	30.77
150*150*150	28	34.46

Table:7 - Compressive strength of Concrete cubes Cast and Cured with Sea water

Compressive strength variation b/w Fresh water and Sea water

3.5 SPLIT-TENSILE BEHAVIOUR:

The 28 days strength of the both concrete cubes which were made with sea water as well the as fresh water were evaluated. The compressive strength of the cubes which were made with sea water is observed to be lower than that of concrete cubes with fresh water. The reasons for decrement in split tensile strength are same as that of compressive strength as explained above.The split tensile strength is in increasing order from 7days to 28days, and by 90days the strength increases gradually in case of M25 reference concrete. The 7 days split tensile strength for M25 grade concrete for potable fresh water mixing and sea water curing is more than the strength of 28days.

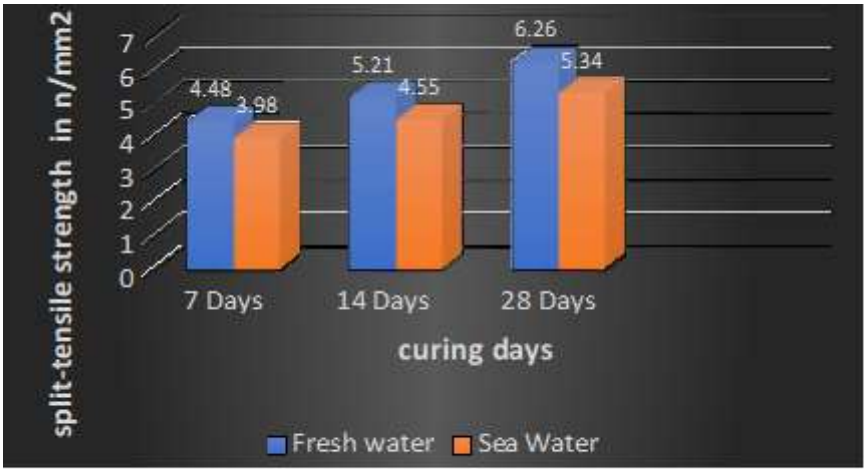
From the above results, it can be observed the as the percentage of salinity increase tensile strength decreases. As percentage of salt content increases that resulted in the reduction of tensile strength of concrete, this is because of salt content causes corrosion and weakens the reinforcement. Hence when the load applied on the specimen crack starts on the circumference of salinity and extends.When compared with reduction in compressive strength, tensile strength reduction is moderate. The results of split tensile strengths are shown in the following tables.

Age of Concrete(days)	**Size of cylinders**	**Average tensile strength(N/mm^2)**
7	150mm* 300mm	4.48
14	150mm* 300mm	5.21
28	150mm* 300mm	6.256

Table 8– Split- Tensile strength of Concrete Cylinders Cast and Cured with Fresh water

Age of Concrete(days)	**Size of cylinders**	**Average tensile strength(N/mm^2)**
7	150mm* 300mm	3.98
14	150mm* 300mm	4.55
28	150mm* 300mm	5.34

Table:9 Split-Tension strength of Concrete Cylinders Cast and Cured with Sea water



Split-Tensile strength variation b/w Fresh water and Sea water

3..6 FLEXURAL BEHAVIOUR:

The flexural strength of M25 grade concrete under potable fresh water and Sea water for mixing and curing at 7 days are more compared to the reference concrete. Concrete with mixing and curing by sea water and the portable fresh water, there is no much reduction or gain in flexural strength for 28 days for M25 concrete. when compared to remaining compressive and tensile strengths the reduction of flexural strength is almost negligible. With the use high cement content in the concrete beams, can control the effect of corrosion on the reinforcement.. The results of flexural strengths for both mixing and curing with sea water and fresh water are given in the following tables.

Age of Concrete(days)	Size of Beams	Average Flexural strength(N/mm^2)
7	150mm* 150mm	6.21
14	150mm* 150mm	6.99
28	150mm *150mm	7.53

Table:11 Flexural strength of Concrete Beams Cast and Cured with Fresh water

Age of Concrete(days)	Size of Beams	Average Flexural strength(N/mm^2)
7	150mm* 150mm	5.23
14	150mm* 150mm	6.12
28	150mm *150mm	7.05

Table:12- Split-Tension strength of Concrete Beams Cast and Cured with Sea water

Flexural strength variation b/w Fresh water and Sea water

3.7 BOND STRENGTH BEHAVIOUR:

The bond strength of M25 grade concrete under potable fresh water and Sea water for mixing and curing at 7 days are more compared to the reference concrete. Concrete with mixing and curing by sea water reduces the bond strength as compared to portable fresh water. There is no much reduction in bond strength for 28 days for M25 concrete. when compared to remaining compressive and tensile strengths the reduction of bond strength is almost less. With the use high cement content in the concrete mix, can reduces the effect of the corrosion in the reinforcement.

4.CONCLUSION

- In this project work, the experiment was conducted on M25 grade of concrete the effect of sea water on compressive strength, flexural strength and split tensile strength of concrete was investigated. There is lower in the strength of concrete specimen cast & cured with salt water as compared to those of cast & cured in fresh water.
- The obtained pH value is 11.96, total hardness value is 190 ppm, but the minimum pH value of Sea water must lie between 7.4 to 8.4 and total hardness value must lie between 90-180 ppm. When the sea water pH and total hardness value comes under minimum requirement then those sea water can be used in concrete construction.
- Although, the compressive strength of the concrete cubes which were casted using sea water shows slightly acceptable. But the surface of cubes casted and cured using sea water has salts in it.
- Concretes mixed and cured in seawater have higher compressive, tensile, flexural and bond strengths than concretes mixed and cured in fresh water in the early ages at 7 and 14 days. But later, the strength will gradually decrease after 14 days for concrete mixes mixed and cured in sea water while the fresh water mixes increase in a gradual manner.
- Cement content in concrete mixes has a great effect on concrete strengths and durability. Higher cement content produces strength five times higher, especially for low water–cement ratios.
- In this project, we can conclude that if the water contains fewer amounts of hardness, PH and salts then there is no reduction in strength. Hence, this water can be used for casting. If reinforcement is needed to be provided, then the structures should be provided with proper admixtures to protect it from corrosion.

Precautions:

With the help of these remedial measures we can use sea water for mixing and curing of structural concrete there are as follows:

1) Anti-chloride admixtures can be used in concrete production to avoid the sea water effect on concrete.
2) Outer covering of un-plasticized poly vinyl chloride (UPVC) tube may also be used to safe guard concrete column against seawater.
3) The usage of SRC in concrete improves the resistance of concrete for deterioration against seawater and salty solutions.
4) Care should be taken in the manufacturing of concrete to produce impermeable dense concrete in order to resist the attack of seawater.

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