World Journal of Engineering Research and Technology
WJERT
www.wjert.org
Impact Factor Value: 5.924

COMPARATIVE STUDY OF STRENGTH OF CONCRETE MADE FROM FRESH AND SALT WATER

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Article Received on 26/08/2020 **Article Revised on 16/09/2020** **Article Accepted on 06/10/2020**

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ABSTRACT

Fresh water is any naturally occurring water such as Lakes, Rivers, Ponds etc that has no dissolved salt, whereas salt water (sea water) is also a naturally occurring water but contains large concentration of dissolved inorganic ions such as sodium, chloride, sulphate, magnesium etc. This paper aimed at comparing the strength of concrete made from both fresh and salt water. Slump and comparative strength tests were performed on concrete made for both water and their initial and final setting time were noted. The paper conclude that concrete made from salt water has higher comparative strength than concrete made from fresh water, but gradually decreases after 28 days. The paper recommends that test should be conducted to evaluate the salinity of water before it is used at any construction site.

KEYWORDS: Freshwater, Seawater, Comparative strength, Slump, Setting time.

INTRODUCTION

Concrete is an artificial engineering material made from a mixture of Portland cement, fine and coarse aggregates and water. It is the most widely used construction material in the world.

Admixtures are chemicals added to the concrete mix to control its setting properties and are used primarily when placing concrete during environmental extreme, such as high or low temperatures, windy conditions etc. Water plays an important role as in preparation of concrete. Water is the main ingredient of concrete as it actively participates in chemical reactions with cement.

Peter (2013) added that concrete provides a wide latitude in surface textures and colours and can be used to construct a wide variety of structures, such as highways, streets, bridges, dams, barge building, airport runways, irrigation structures, breakwaters, piers and docks, sidewalks.

Other desirable qualities of concrete as a building material are it strength, economy, and durability. Depending on the mixture of material used, the tensile strength of concrete is much lower, but by using properly designed steel reinforcing, structural members can be made that are as strong in tension as they are in compression. The durability of concrete is however depend on different type of concrete, the names of some are distinguished by the types, sizes and densities of aggregate. e.g normal height or heavy weight.

Concrete are similar in composition to mortar, which are to bond unit masonry. Mortars however, are normally made with material like cement or lime and an inert material, fine aggregate like sand. Whereas, concrete contain much larger aggregates and this usually have greater strength.

As the result, concrete have a much wider range of structural application, including pavements, footing, pipes, unit majoring, walls, dams, and tanks, because ordinary concrete is much weaker in tension than in compression, it is usually reinforced with a much stronger materials such as steel, to resort tension.

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.

The reduction in strength increases with an increase in exposure time, which may be due to salt crystallization formation affecting the strength gain.

Concrete of higher grades is used for massive constructions which in turn contains highly calcinated cement. Sulphates potassium and magnesium sulphates (K_2SO_4 and $MgSO_4$) in particular are major hazards to the calcium hydroxide $Ca(OH)_2$ present in the cement forming soluble magnesium hydroxide $Mg(OH)_2$ which forces the reaction to form gypsum (Swamy, 2018).

Further, when mixed with concrete, the chloride ions present in seawater corrode the steel reinforcement by causing the expansion of steel (salt production). This effect is more dangerous in concrete structure exposes to air.

The chemical reaction of the cement paste with the high chloride content of seawater is generally slight and not a primary cause of concern. Sodium and potassium ions may produce or intensify the alkali aggregate reaction if reactive types are used, and sulphate and magnesium ions cause a weakening action on the cement paste (Uddin *et al*. 2014).

According to Raki *et al* (2010), concrete mixed with seawater has more compressive strength values in initial 7 and 14 days of setting than concrete mixed with fresh water, but decreases rapidly after the time period. The chlorine reactions on reinforcement steel produce salts which further produce cracks internally on the concrete. Hence, using fresh water for mixing and curing of concrete is more suitable option in marine construction.

MATERIALS AND METHODS

Granite was obtained from a quarry site in Akamkpa, Cross River State, and was thoroughly washed (to remove unwanted materials) and sun dried. The cement used in the study was the Dangote brand of ordinary Portland cement, while the fine aggregate was obtained from Abiakpo River. Fresh water used for the test was free from impurities such as silo, clay, acids, organic matters and sewage, because it has no pronounced taste on odour.

Salt water (sea water) which is a complex solution of many salts containing living matter, suspended silt, dissolved gases and decaying organic material was obtained from a sea passing across Uta-Ewa in Ikot Abasi Local Government Area.

A mix ratio of 1: 1½:3 was used for all the samples. The dried ingredients were mixed for one minute, and the water content was added and mixed further for three minute.

For slump test experiment

- The cone mould was placed on a flat base and clamped into position.
- A scooper was then used to scoop the concrete and the clamped cone mould was filled in three layers, each layer was tamped 25 strokes evenly over the cross section with a metallic tamping rod and the top surface was leveled.
- The clamp was released and the mould was vertically left to allow the concrete to slump.
- The inverted cone was placed alongside on the base plate and a straight edge was laid a cross and the height of the slump was measured with a ruler from the straight edge down to the top of the concrete to find the slump value in millimeters (mm).
- The test was then repeated, using concrete made from salt water and the results were recorded.

On the other hand, test on compressive strength required 36 cubes of concrete which was also prepared using a mix ratio of 1: 1½: 3.

- The concrete was filled into the mould in two equal layers approximately and vibrated mechanically and each distributed over the mould surface. The sides of the cube was carefully troweled and the top was smooth off.
- The top of the cubes were covered with polythene sheet and a damp sacks were placed over them for 24hours.
- The cubes were de-mould and their tops were marked for easy identification.
- The cubes were cured in fresh and salt water for 7, 14, 21 and 28 days respectively.
- The cubes were removed, wiped out and weighed and 3 cubes were tested per days of curing.
- The crushing loads were determine and recorded.

RESULTS AND ANALYSIS

The results obtained from the above mentioned tests show that the value of slump test recorded from concrete made from fresh water was 54mm, while a value of 86mm was recorded from concrete made from salt water. This result shows that the high workability of concrete made from salt water can be as a result of hardness in salt water.

On setting time, the concrete made from fresh water had an initial setting time of 1hr. 58min. and a final setting time of 3hrs. 35min., while concrete made from salt water had an initial setting time of 1hr. 43min. and a final setting time of 2hrs. 27min.

This result as explained by Rocco and Elices (2009) indicates that salt water decreased the setting time of concrete when compared with fresh water.

Table 1: Compressive strength of concrete mixed and cured with fresh water (ff) for 7 days.

Sample	Weight (Kg)	Area (mm^2)	Ultimate Load (KN)	Compressive Strength (N/mm^2)
1	8.01	22500	504	22.40
2	8.14	22500	503	22.35
3	8.12	22500	501	22.26

Table 2: Compressive strength of concrete mixed and cured with fresh water (ff) for 14 days.

Sample	Weight (Kg)	Area (mm^2)	Ultimate Load (KN)	Compressive Strength (N/mm^2)
1	8.0	22500	508	22.58
2	8.12	22500	499	22.18
3	8.08	22500	507	22.53

Table 2: Compressive strength of concrete mixed and cured with fresh water (ff) for 21 days

Sample	Weight (Kg)	Area (mm^2)	Ultimate Load (KN)	Compressive Strength (N/mm^2)
1	8.03	22500	605	26.89
2	8.15	22500	610	27.11
3	8.18	22500	613	27.24

Table 4: Compressive strength of concrete mixed and cured with fresh water (ff) for 28 days

Sample	Weight (Kg)	Area (mm^2)	Ultimate Load (KN)	Compressive Strength (N/mm^2)
1	8.16	22500	710	31.56
2	8.11	22500	689	30.62
3	8.14	22500	711	31.60

Table 5: Compressive strength of concrete mixed with fresh water and cured with salt water (fs) for 7 days

Sample	Weight (Kg)	Area (mm^2)	Ultimate Load (KN)	Compressive Strength (N/mm^2)
1	8.06	22500	505	22.44
2	8.10	22500	504	22.40
3	8.11	22500	502	22.31

Table 6: Compressive strength of concrete mixed with fresh water and cured with salt water (fs) for 14 days

Sample	Weight (Kg)	Area (mm^2)	Ultimate Load (KN)	Compressive Strength (N/mm^2)
1	8.14	22500	503	22.36
2	8.10	22500	506	22.49
3	8.06	22500	505	22.44

Table 7: Compressive strength of concrete mixed with fresh water and cured with salt water (fs) for 21 days

Sample	Weight (Kg)	Area (mm^2)	Ultimate Load (KN)	Compressive Strength (N/mm^2)
1	8.09	22500	504	22.40
2	8.11	22500	504	22.40
3	8.03	22500	506	22.49

Table 8: Compressive strength of concrete mixed with fresh water and cured with salt water (fs) for 28 days.

Sample	Weight (Kg)	Area (mm^2)	Ultimate Load (KN)	Compressive Strength (N/mm^2)
1	8.13	22500	502	22.31
2	8.10	22500	498	22.13
3	8.17	22500	504	22.40

Table 9: Compressive strength of concrete mixed and cured with salt water (ss) for 7 days.

Sample	Weight (Kg)	Area (mm^2)	Ultimate Load (KN)	Compressive Strength (N/mm^2)
1	8.02	22500	712	31.64
2	8.10	22500	699	31.07
3	8.14	22500	698	31.02

Table 10: Compressive strength of concrete mixed and cured with salt water (ss) for 14 days.

Sample	Weight (Kg)	Area (mm^2)	Ultimate Load (KN)	Compressive Strength (N/mm^2)
1	8.16	22500	687	30.53
2	8.12	22500	700	31.11
3	8.06	22500	682	30.31

Table 11: Compressive strength of concrete mixed and cured with salt water (ss) for 21 days.

Sample	Weight (Kg)	Area (mm^2)	Ultimate Load (KN)	Compressive Strength (N/mm^2)
1	8.14	22500	685	30.44
2	8.11	22500	687	30.53
3	8.09	22500	695	30.89

Table 12: Compressive strength of concrete mixed and cured with salt water (ss) for 28 days

Sample	Weight (Kg)	Area (mm^2)	Ultimate Load (KN)	Compressive Strength (N/mm^2)
1	8.12	22500	485	21.56
2	8.11	22500	474	21.07
3	8.14	22500	497	22.08

On compressive strength test, the results obtained from the experiment of concrete mixed and cured with fresh water for 14 days as shown in table 2 indicates that sample 1 has the highest strength of 22.58N/mm^2. Concrete mixed with fresh water and cured with salt water for 14 days as shown in table 6 indicates that sample 2 has the highest strength of 22.49, while concrete mixed and cured with salt water for the same numbers of days as shown in table 10 has the highest strength of 31.11N/mm^2. From the result, it is noted that the higher the failure load, the highest the cube strength and the lower the failure load, the lower the cube strength. The above analysis also shows that concrete mixed and cured with salt water has the highest compressive strength. This is because the rate of strength gain in fresh water cubes is slow when compared with salt water.

CONCLUSION

- Concretes mixed and cured in salt water have higher compressive strength than concrete mixed and cured in fresh water in the early ages at 7, 14, 21 days. The strength at 28 days for concrete mixed and cured in fresh water increased in a gradual manner.
- Strengths are also affected by the aggregate type/size, and properties and cement type, age and curing conditions but with a lower rate than the effect of cement content.
- Maximum compressive strength for the three concrete samples were obtained at 28 days of curing.

RECOMMENDATIONS

Based on the tests and results obtained, the following recommendations were made:

- Care should be taken during the production of concrete in order to reduce the attack of seawater.
- Sulphate Resisting Cement (SRC) should be used in communities with high rate of seawater.
- A meaningful test should be conducted to evaluate the salinity of water before it is used at any construction site.
- Any products containing chloride chloride such as fertilizer should be avoided during concrete mix. This is because the mild acid will attack the bonds that holds concrete together

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