Experimental Study On Performance of Seawater Concrete Beams

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***Abstract*: The main objective of this Thesis is study the performance of seawater concrete beams reinforced with glass fiber rebars (GFRP) when using seawater as mixing or curing water. Experimental Work includes three beams were tested with rectangular section its dimensions (200 * 500 * 2200) mm, divided into two groups, using different mixing water (F)or(S) represent as fresh water and natural seawater respectively with using ordinary Portland cement in all mixes . We studied the effect of using seawater on flexural capacity of tested beams in fist group, while the second group showed the effect of changing curing water from fresh water to seawater. Analysis of test results shows that the use of seawater in concrete mixtures will become possible in the future. The pattern of cracks, final mode of failure, and deformational characteristics were recorded. Finally, analysis of test results were reported.**

Keywords: **seawater; performance; GFRP; Freshwater.**

1. INTRODUCTION

The World Health Organization (WHO) estimates that Drinking water insufficiency is expected to affect approximately more than half of the world's population by 2025[1]. Furthermore, natural catastrophes often lead to shortages of fresh water in the affected areas. The construction industry accounts for approximately 12% of fresh water consumption. The use of seawater as the mixed water in reinforced concrete will result in a reduction in freshwater consumption, the world concrete industry consumes more than 2 billion tons of freshwater annually, so seawater may become a substitute for concrete production in the sustainable construction industry.

Concrete is widely used in the construction industry around the world. Annually, a large amount of freshwater is consumed, representing by about 9% of global industrial water consumption. According to predictions, by 2050, 75% of the water need for concrete manufacturing will be met, and it will most likely occur in locations where there are likely to be water shortages. Because of the global increase in freshwater scarcity and the negative environmental effects of desalination, seawater is becoming a viable alternative for concrete mixing water.

Seawater, which cover 96.5 % of world's accessible water [2] could be a good alternative to fresh water for concrete production, specifically in coastal areas where fresh water is limited. Because seawater is considered as renewable resource, unlike fresh water which is generally a nonrenewable resource so using it as a mixing water in concrete improves concrete long-term viability.

It is effective to use sea water when mixing concrete [3].Previous studies indicate that sea water showed a good performance as mixing water in concrete mix. In the last century or earlier many structures have been successfully constructed using seawater concrete along the coasts of Southern California and Florida.

Chemical agents have an impact on the durability of concrete structures. This could lead to rapid deterioration, reducing their service life and spend a lot of money on repairs and maintenance also it causes steel corrosion.

Steel corrosion problems can be solved by using seawater without reinforced materials, or by using materials don't rust like fiber-reinforced polymers (FRP) in reinforced concrete structures [4].

2. EXPERIMENTAL WORK

Three R.C. beams with rectangular cross-section, sized 200 mm (width) x 500 mm (height) x 2200 mm length, were manufactured and tested as shown in Figure (1).

Two parameters were considered in this study; changing mixing water and curing regime.

Details of tested specimens with different parameters are shown in Table (2).

The flexural behavior of reinforced concrete beams with different mixing and curing water is the main objective of the study. Therefore, a total of three beams classified into 2 groups as shown in Table (2).

The first group have two tested specimens with the same type of cement ordinary Portland cement (O) and curing condition (fresh water) but the only change in mixing water [fresh water (F) and natural seawater (S)].The second group consisting of two beams with the same type of mixing water seawater S) and cement type (OPC) but the only change in curing condition such (fresh water or seawater).

Concrete mix used to cast the tested RC beams have concrete compressive strength 25MPa consisted of Portland cement, natural aggregates, and mixing water could be fresh water or seawater as shown in Table (1) .

Mixing is performed using a concrete drum mixer with maximum capacity 0.125 m3. Sand, dolomite and cement were dry mixed for about until a homogenous color.

Then the water was gradually added while mixing was continued for two minutes. The concrete was cast in the molds and cured at about 95 percent relative humidity.

The total three beams were tested as simply supported beams under one vertical concentrated static load at the mid-span using a hydraulic jack of 500 KN capacity. Loading was applied incrementally; the incremental vertical load was applied in 5 KN increments .

Digital Load cell of capacity of 550 kN with accuracy of 0.1 kN was adopted to measure the applied loads. The values of the applied loads were recorded from the monitor connected to the load cell. The beams were tested using an incremental loading procedure. The vertical displacement of the tested beams was recorded using two electric dial gauges, one at the middle of beams and the other at distance equal to one fourth lengths from the support. During tests, after 30% from applied load, the displacement was kept constant at each load stage for measuring and observing.

3. TEST RESULTS AND ANALYSIS

In this part, the behavior RC beams for the two groups are analysis. Comparing between cracks patterns and load deflection curves are discussion. The values of ultimate loads are analysis.

3.1. Crack Patterns and Modes of Failure

The crack patterns and mode of failures shows in figure (2) for tested R.C beams, The cracks were initiated vertically at mid-span and the failure mode for RC tested specimens did not change, it was flexural failure one which usually accompanied by rebar tensile rupture, the cracks width increased and the numbers of cracks at tension zone near the main reinforcement decreased when using seawater instead of freshwater.

3.2. Load Deflection Curved

From groups G1, we find that the stiffness of tested specimens decreased by using seawater as mixing water ,and for G2 using seawater as mixing and curing recorded a little decrease in stiffness . The reduction in stiffness when using seawater may occurred due to combined attack of chloride and sodium sulphate.

3.3. Failure Load

Crack propagation for selected beams are as shown in Figure (2), the cracks were initiated vertically at mid-span and the failure of tested beams (F-F, S-F and S-S) occurred at load 210 KN, 169.3KN and 164.7 Kn respectively.

4. CONCLUSIONS

Based on the analysis of the experimental results of the tested RC beams, the following conclusions can be drawn:-

1. By using seawater the flexural strength capacity of beams decreased and the number of cracks decreased compared to beam (F-F).

2. Flexural failure mode didn't change for all tested beams, it was flexural failure one which usually accompanied by rebar tensile rupture.

3. Changing curing regime from fresh water to seawater has negligible effect on the flexural capacity of tested RC beams.

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APPENDIX

List of Tables

Table (1): mix design

MIX	Mixing water	CEMENT TYPE	Water	Cement	SAND	C.STONE	CURING
1	F	O	180	350	750	1120	F
2	S	O					F
3	S	O					S

Table (2): The Experimental Program

GROUP No.	Specimen Cod	Mixing water	Type of cement	Curing water
GROUP 1	F - .F	F	Ordinary Portland cement	F
	S - F	S		F
GROUP 2	S - F	S		F
	S - S	S		S

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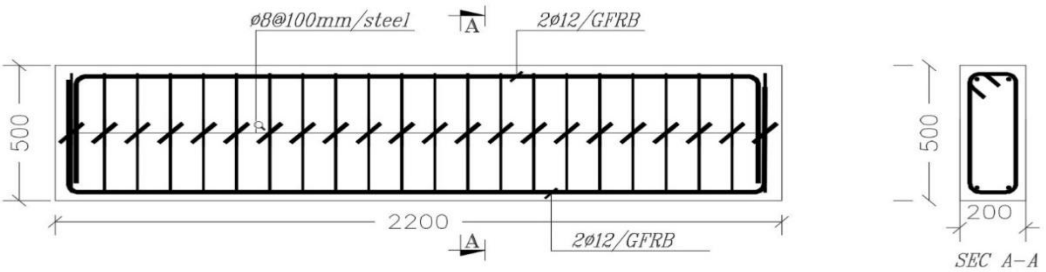
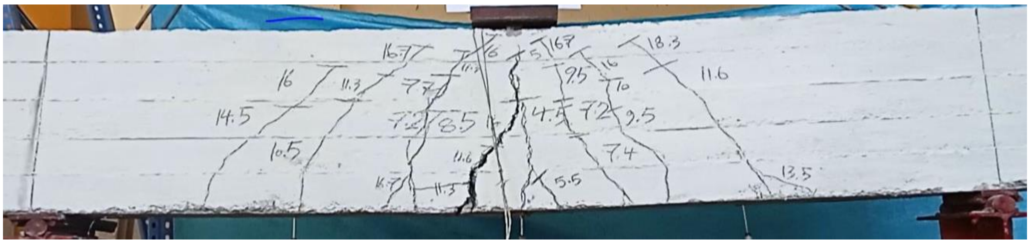
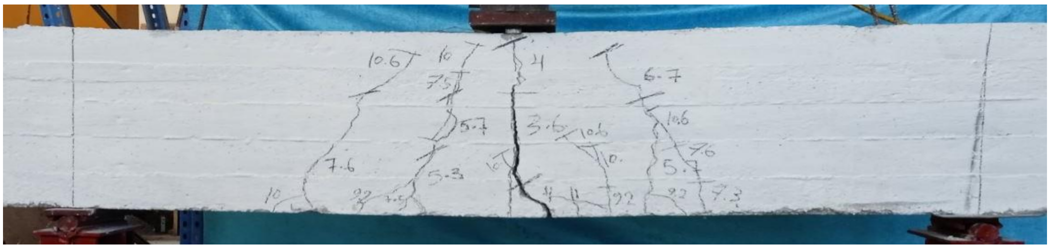


Fig. (1): Typical Detail for the tested RC beams.



(a) Tested beam (F-F)

(b) Tested beam (S-F)



(C) Tested beam (S-S)

Fig. (2): Crack Pattern at failure for tested beams

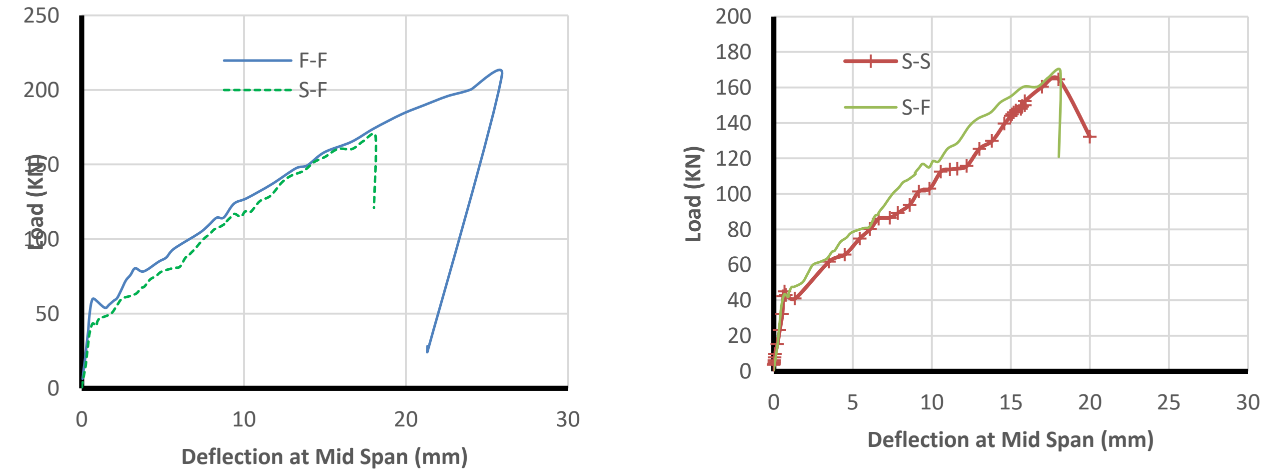


Fig. (3): Load Deflection curves at Mid Span for tested beams