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Study the effect of hybrid steel on concrete column mixed with sea water under axial Load

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Abstract.

This paper presents experimental and analytical investigations on the axial capacity of 12 columns using hybrid steel and different types of water. The use of hybrid steel for reinforcing has been confirmed in recent years for stamping out corrosion in steel. One of the main objectives of this study is to examine the effects of using hybrid steel on the compressive strength of R.C columns after mixing with variable water (fresh water, sea water, and 50% freshwater +50% Seawater).

12 reinforced concrete columns used in the experimental program. 9 columns with different weight percentages of steel fiber (16%, 33%, and 50%) from the total Required RFT were studied. For the remaining 3 specimens, one column was tested and used as the control column. In order to compare the compressive strength of our experiment, other side we also poured 18 cubic and 12 cylinders (3 specimens of sea water, 3 specimens of pure water, and 3 specimens of "50% seawater + 50% pure water"), which were checked in 7 days and the same number in 28 days.

Keywords: Column, exposure the corrosion, Hybrid fiber, Sea Water.

1. INTRODUCTION

One major issue facing reinforced concrete (RC) structures exposed to environment, like parking garages, bridges, and marine structures, is the corrosion of the reinforcing steel. The process of corrosion may result in a loss of serviceability or even the inability to support a given load. Because it is noncorrosive, hybrid steel, a composite material consisting of fibers embedded in a polymeric resin, is an alternative to steel reinforcement in reinforced concrete (RC) constructions. Moreover, FRP materials have exceptional nonmagnetic, high tensile strength, and light weight characteristics that make them a good fit for structural engineering applications. However, FRP rebar's show signs

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of brittle structural behavior [1]. To get past this shortcoming, it is proposed to use hybrid steel-FRP rebar's to improve both the ductility and corrosion resistance of the reinforcing bars. Short coming, it is suggested to employ hybrid steel rebar's to enhance the reinforcing bars' ductility and corrosion resistance. Few studies have addressed the behavior of members subjected to axial compression loads, such as columns, in the context of hybrid steel reinforced members; most research investigations have focused on flexural members. Only 30% to 60% of the tensile strength, ductility, and corrosion resistance of the reinforcing bars make up the low compression strength of FRP reinforcement, which restricts its use in compression members. Few studies have addressed the behavior of members subjected to axial compression loads, such as columns, in the context of hybrid steel reinforced members; most research investigations have focused on flexural members. FRP reinforcement's application in compression members is limited by its low compression strength, which accounts for only 30% to 60% of its tensile strength [2]

There are many advantages of introducing Hybrid steel in construction industry however there are also drawback and limitation of using Hybrid steel. Hybrid steel can be defined as a type of steel which surrounded by glass fiber to increase steel behavior against corrosion in additional to increase yielding of steel. In order to overcome the defects of concrete material, many researchers have conducted a lot of to improve the properties of concrete, especially its toughness. It has been proved that the usage of fibers can improve the mechanical properties and durability of concrete. A large number of studies have been conducted to study the performance and advantages of fiber- reinforced concrete in the last several decades. The fibers often used in concrete materials include steel fiber, glass fiber, polyethylene fiber, polypropylene fiber, polyester fiber, basalt fiber, and natural fiber. In recent years, the use of hybrid steel has become increasingly popular for civil infrastructure applications, it enhances the strength and ductility of concrete by forming perfect adhesive bond between. [3]

The Addition of reinforcing tubers to provide equal mechanical properties at a greatly reduced weight is often an important reason for choosing composites over traditional structural materials another vital consideration is the substitution of easily available resources for essential components in short supply or those that can only be obtained from foreign sources. imported strategic materials because they are made from easily available local supplies like carbon, polymers, ceramics, and common metals. Fibers that serve as reinforcements are used to make composite materials. On the other side increasing in world population may have significant effects on global resources in addition to climate change. For instance, otherwise in some places of the world freshwater will be in short in supply and difficult to get. According to the World Meteorological Organization (WMO), by 2025, more than half of the world's population will be unable to obtain sufficient drinking water. From there on, the use of Sea Water concrete has been widely spread across other countries such as USA, United Kingdom and Sweden.

Several billion tons of freshwater are needed annually in the concrete industry around the world for mixing, curing, and cleaning. [5]

The authors feel that the possibility of using seawater as the mixing water in concrete should be seriously examined from the standpoint of conserving freshwater. Furthermore, allowing the use of seawater as a concrete material would be extremely easy and cost-effective in building, particularly in coastal projects. However, most reinforced concrete standards prohibit the use of seawater due to the potential of early reinforcement corrosion caused by chloride (Cl) in seawater compounds. [5]

2. MATERIALS and Methodology

2.1 Materials

Locally accessible materials, such as fresh water or sea water, dolomite, sulfate-resistant cement, and sand, were utilized to cast the specimens. After 28 days, a mix was created to achieve bars of glass fiber Reinforcement bars made locally of normal mild steel and high tensile steel were used. Examinations The Egyptian Standard Specifications were followed in order to ascertain the characteristics of these materials the desired cubic compressive strength of 250 kg/m2. The results

were compared to the limitations specified in these particular The surface texture is usually homogeneous and smooth. The gravel that was used had a nominal maximum size of 19.00 mm. The gravel used in the appendix is graded.

Cement: SRC, or Portland Sulphate-Resisting Cement. Tests conducted on various cement batches made available for this study effort produced more or less comparable findings, demonstrating the consistency of the utilized cement batches. It is in line with Egyptian requirements. The standard analysis and the physical attributes of the CEM IV/A (P) 42.5N-SR cement batches utilized in this study as established by the laboratory tests demonstrate the cement's appropriateness for concrete works.

Sand: The siliceous materials in the sand were free of impurities; the amount of silt, and clay in it did not exceed 1% by weight. Moreover, they were devoid of anti-materials. Figure 1 depicted the sieve analysis for fine aggregate Water: Seawater was obtained from the red sea, and all of the mixtures were made with clean, impurity-free drinking water. Figure 2 depicted the sieve analysis for coarse aggregate Steel Reinforcement: Two distinct types of steel were used in column 240 N/mm2 for stirrups and on the other side 360 N/mm2 for longitudinal bars.

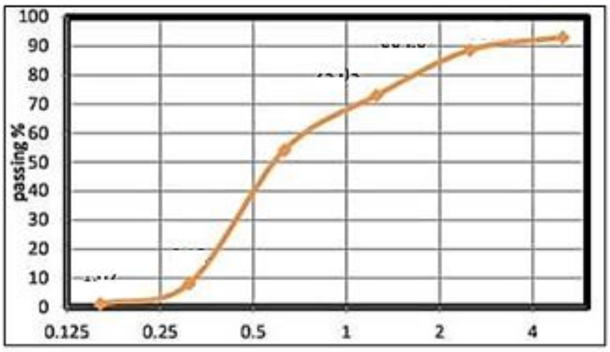

Fig 1: fine aggregate sieve analysis

Fig 2: Coarse sieve analysis

2.2 Methodology

twelve concrete columns with a crossed diameter of 250 mm and a total length of 1000 mm. All tested columns were loaded with centric vertical loads, and nine of the columns were reinforced with hybrid steel at varying percentages of 16, 33, and 50% from the total bar diameter. Pure water or sea water was used as mixing water in varying ratios. Table 1 displays all specimen details, including RFT and column concrete dimensions.

2.2.1 Concrete Mix

All of the tested concrete columns were cast using a concrete mix that had a compressive strength of 25MP (fresh water + sea water + 50% sea water + 50% pure water). To select, numerous trial mixes were created. Table (1) displays the weight proportions of the mixture. The mixture had a w/c ratio of 0.5, with natural sand serving as the fine aggregate and a maximum nominal aggregate size of 10 mm for the coarse aggregate.

2.2.2 Compressive strength of concrete

The study took thirty different concrete mixes into account. Six-cylinder concrete mixes were combined with 50% seawater and 50% fresh water (SFS) and cured in seawater. Meanwhile, three mixes were mixed and cured in seawater (SS), three mixes were mixed and cured in fresh water (FS), and three mixes were mixed and cured in seawater. Compression tests were conducted on the concrete mixes at 7, 28, and 72-hour ages.

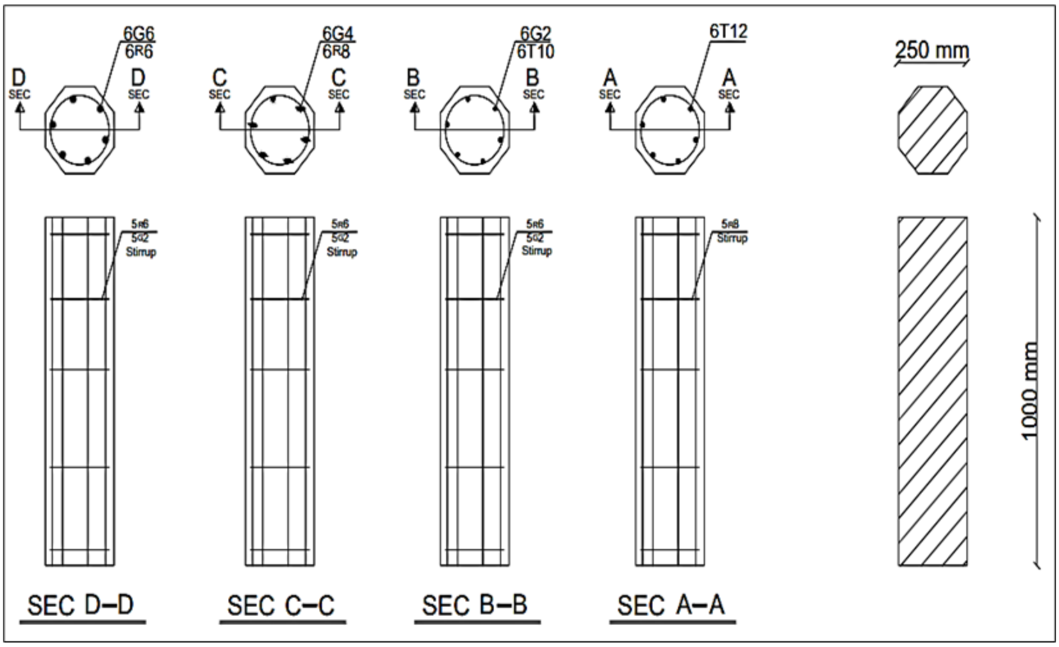

Fig 3: Sample of RFT inside column specimen

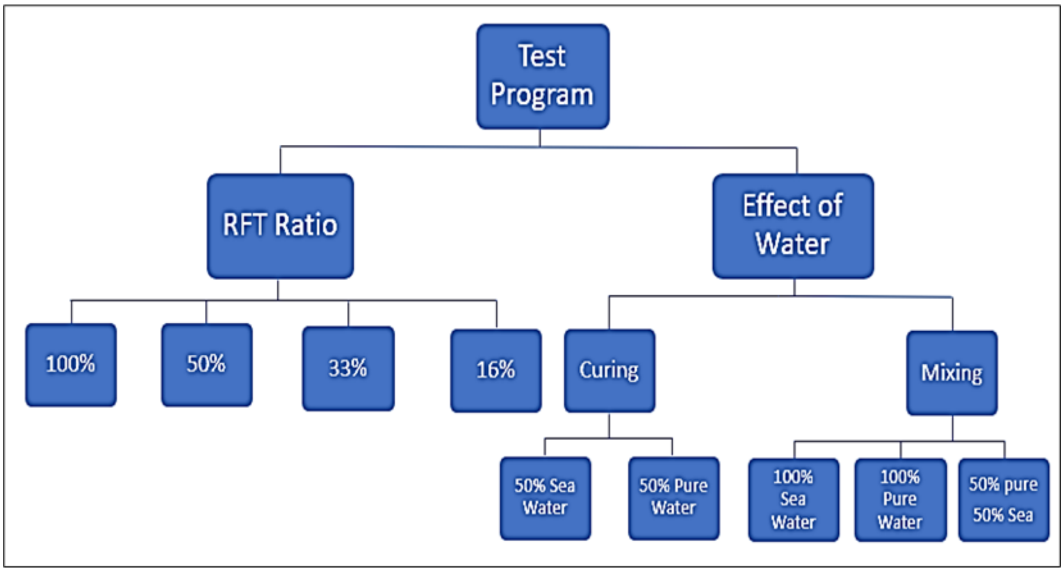

Fig 4: Test Program

2.2.3 Main Test Program

To investigate the above Figure, nine columns will be cast the hybrid steel and three concrete columns Will not have G-Fiber (pure Steel).

We are dividing our specimen to 4 group each group consists of 3 types of columns

Type 1: using 6 bars phi 10 mm surrounded by 2 mm glass fiber

Type 2: using 6 bars phi 8 mm surrounded by 4 mm glass fiber

Type 3: using 6 bars phi 6 surrounded by 6 mm glass Type 4: using 6T12 pure steel

3. RESULTS AND Discussion

3.1 Compressive stress test

We obtain experiment result from material lab faculty of engineering Helwan university Matria branch, Cairo

As shown in Table 1 below, shows the result of cubes for obtaining compressive strength of concrete

Other side as shown in Table 2 below, shows the result of cylinder for obtaining in direct compressive strength of concrete

Table 1 : 7- & 28-Days compressive test

Type of water in mixing	Load in KN 7Days	Stress in KN/cm2 7 Days	Load in KN 28 Days	Stress in KN/cm2 28 Days
Sea Water	445	1.97	538	2.39
	503	2.23	542	2.4
	512	2.27	580	2.57
Pure Water	507	2.25	533	2.36
	404	1.79	569	2.52
	448	1.99	540	2.4
50% Sea Water 50% Pure Water	385	1.71	535	2.37
	424	1.88	520	2.31
	403	1.79	546	2.42

Table 2: 7- & 28-Days in-direct Compressive test

Type of water in mixing	Load in KN 7 Days	Stress in KN/cm2 7 Days	Load in KN 28 Days	Stress in KN/cm2 28 Days
Sea Water	155	0.88	133	0.75
	134	0.76	100	0.57
Pure Water	105	0.59	155	0.88
	118	0.67	173	0.98
50% Sea Water 50% Pure Water	124	0.70	149	0.85
	128	0.72	113	0.64

3.2 Axial Load in Column

Four Groups was examined into Concrete lab faculty of engineering Helwan university Matria branch, Cairo and the results obtain as shown below

that is lead to calculate the ultimate load acting on each column in three cases

in case of pure water (100%)

in case of (50% pure water &50% seawater)

in case of sea water (100%)

3.3 Group one

3.3.1 Crack Patterns and Failure Loads

The first crack appeared either at the Top of the Column zone, and some finer cracks appeared in the bottom, all tested column failed after the propagation of cracks downwards to the loading region, and location of cracks was almost exclusively at Top zones photo 1,2, and 3 depicts the cracking pattern of specimen C1, C3, C6

Photo1: C1

Photo2: C3

Photo3: C6

3.3.2 Measured Strain

The mid and upper quarter sections of the primary reinforcing steel bars housed the strain gauges. Observe that (S1-sf 16%-(50%Cf. 50%Cs)), (S3-sf 16%-(100%Cf. 0%Cs)), and (S6-sf 16%-(0%Cf 100%Cs)) are the results. For all three specimens, the relationship was linear; however, only specimen number six remained linear until the failure load was reached. We note that the maximum strain in the upper quarter of the RFT bar is 923, corresponding to (S6-sf 16%-(0%Cf.100%Cs)). We note that the maximum strain is 6150, which is based on the strain curves depicted in Figure 5-6

(S3-sf 16%-(100%Cf. 0%Cs)).

Table 3: Group (1) Crack and Failure Loads

Group	Column No	Mode of failure	Cracking Load (KN)	At Failure		
				P failure (KN)	Axial Displacement (MM)	P Crack /P failure
Group 1	C1	Crushing	670	887	10.29	0.75
	C3	Crushing	648	717	37.7	0.90
	C6	Crushing	743	1176	37.9	0.63

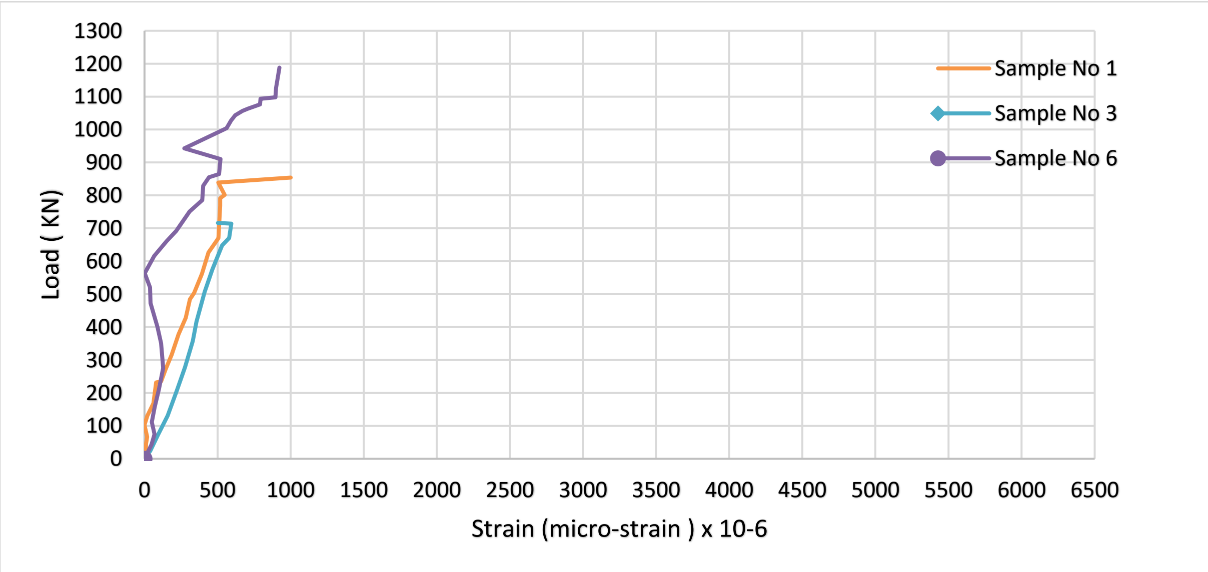

Fig 5: Strain for Mid part of the RFT bar

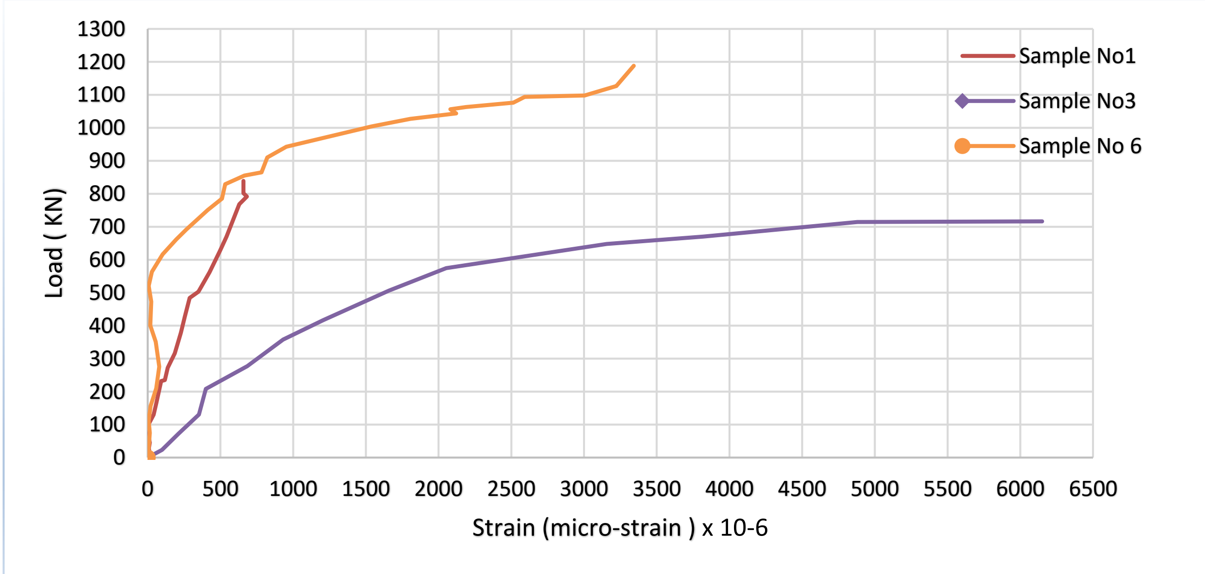

Fig 6: Strain for upper quarter part of the RFT bar

Indicated that

S refer to : Column Number

Sf refer to: Glass Fiber Ratio In parameter

Cf refer to: Fresh Water Ratio In mixing

Cs refer to: Sea water ratio in mixing

VF refer to: volume of G-Fiber from total bar diameter

3.4 Group two

3.4.1 Crack Patterns and Failure Loads

All tested columns failed after the cracks spread downward to the loading region, with the majority of the cracks appearing at the top zones of the column. The first crack was either at the top of the column zone, and some finer cracks also appeared at the bottom. The tested columns in group 2's cracking patterns are displayed in photo 4,5,and 6 following failure. The first crack developed in column (S2-sf 33%-(50%Cf. 50%Cs).) with volume fraction (Vf) = 33% at a load of roughly 667 KN. As the load increased, more cracks started to show up through the upper quarter of the column, and at a load of roughly 770 KN, the column gave way. S7-sf 33%-(100%Cf. 0%Cs).) is a column that contains

the first crack developed at a load of roughly 390 KN, volume fraction (Vf) = 33%. More cracks started to show up as the load increased, passing the upper quarter of the column, and the column finally failed at a load of roughly 900 KN. Column (0%Cf.100%Cs).-S9-sf 33%- The first crack developed at a load of roughly 570 KN, containing volume fraction (Vf) = 33%. As the load was increased, more cracks started to show through the column's upper quarter, and at a load of roughly 867 KN, the column broke. Concentrated loads caused cracking, with the major propagating through the top zone in the loading area, and these failure crack patterns were almost identical for the three tested columns (C2, C7, and C9).

Photo 4 :C2 **Photo 5:** C7 **Photo 6:** C9

3.4.2 Measured Strain

The strain gauges were located in the mid height column attached to the main reinforcing steel bars. From the results that observe that (S2-sf 33%-(50%Cf. 50%Cs)),(S7-sf 33%-(100%Cf. 0%Cs)), (S9-sf 33%-(0%Cf .100%Cs)). The relationship was linear for the three specimens.

We observe that max strain in upper quarter part of the RFT bar equal to 1490 which founded into (S7-sf 33%-(100%Cf. 0%Cs)).

We observe that max strain equal to 11947 which founded into (S2-sf 33%-(50%Cf. 50%Cs)),

Strain curves shown in Figure 7-8

Table 4: Group (2) Crack and Failure Loads

Group	Column No	Mode of failure	Cracking Load (KN)	P failure	At Failure Axial Displacement (MM)	P Crack /P failure
Group 2	C2	Crushing	667	770	10.85	0.86
	C7	Crushing	390	900	9.05	0.36

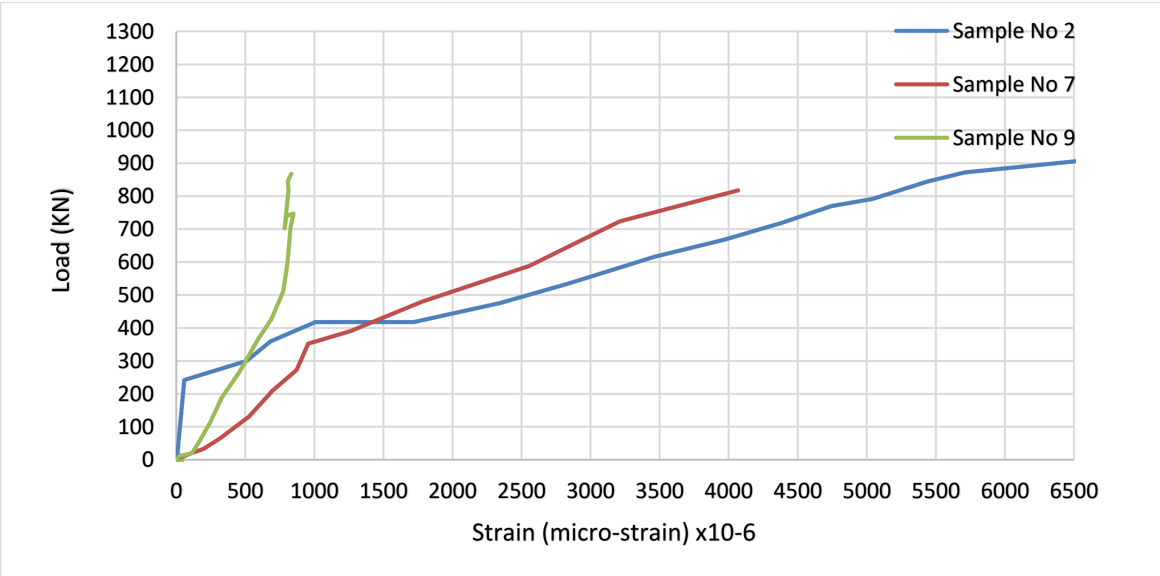

Fig 7: Strain for upper quarter part of the RFT bar

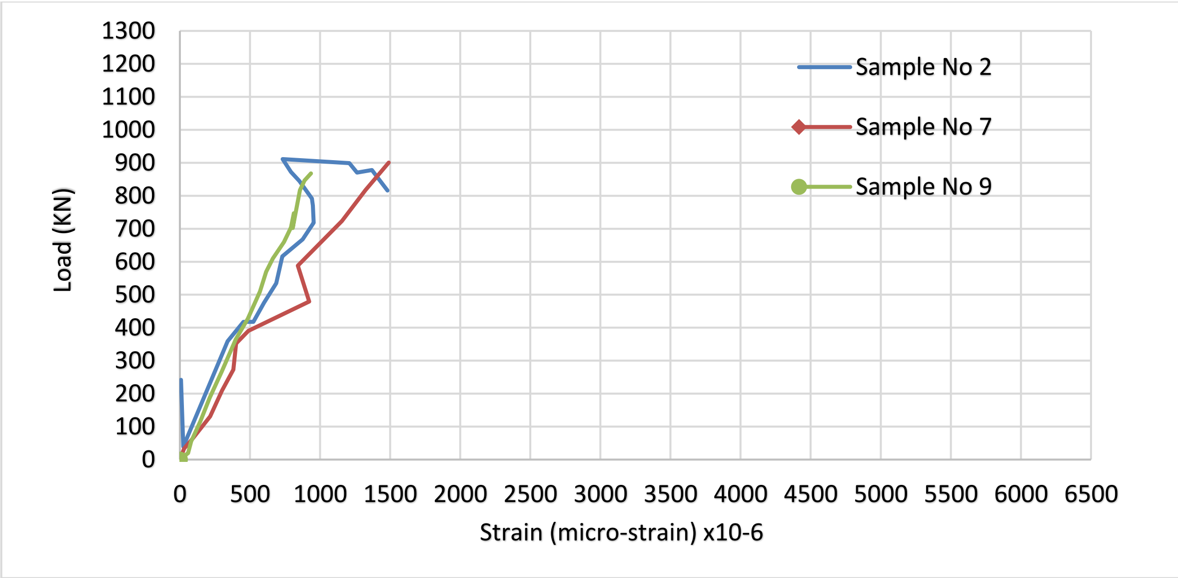

Fig 8: Strain for Mid part of the RFT bar

Indicated that

S refer to: Column Number

Sf refer to: Glass Fiber Ratio In parameter

Cf refer to: Fresh Water Ratio In mixing

Cs refer to: Sea water ratio in mixing

VF refer to: volume of G-Fiber from total bar diameter

3.5 Group three

3.5.1 Crack Patterns and Failure Loads

All tested columns failed after the cracks spread downward to the loading region, with the majority of the cracks appearing at the top zones of the column. The first crack was either at the top of the column zone, and some finer cracks also appeared at the bottom. The tested columns in group 3's cracking patterns are displayed in Photo 7, 8, and 9 following failures. The S8-sf 50%-(100%Cf. 0%Cs) Column At a load of roughly 673 KN, the first crack emerged, containing volume fraction (Vf) = 50%. More cracks started to show up as the load increased; passing the upper quarter of the column, and the column finally broke at a load of roughly 832 KN.

containing volume fraction (Vf) = 50%, the first crack emerged at a load of roughly 560 KN (S11-sf 50%-(0%Cf. 100%Cs).). More cracks started to show up as the load increased, passing the upper quarter of the column, and the column finally failed at a load of roughly 895 KN. 50%-(50%Cf. 50%Cs) in S12-sf At a load of roughly 375 KN, the first crack developed, containing volume fraction (Vf) = 50%. More cracks started to show up as the load increased; passing the upper quarter of the column, and the column finally broke at a load of roughly 719 KN. The three tested columns (C8, C11, and C12) had failure crack patterns that were almost identical in that concentrated loads led to cracking, with the majority propagating through the loading area experiments' top zone for the tested specimens in Group 3.

Photo 7: C8 **Photo 8**: C11 **Photo 9**: C1

3.5.2 Measured Strain

The mid-height column's strain gauges were fastened to the primary steel bars that provided reinforcement. (S8-sf 50%-(100%Cf. 0%Cs)), (S11-sf 50%-(0%Cf.100%Cs)), and (S12-sf 50%-(50%Cf.50%Cs)) are the findings that indicate this. With regard to the three specimens, the relationship was linear. The maximum strain in the upper quarter of the RFT bar, as we can see, is 6135, which is based on (S12-sf 50%-(50%Cf.50%Cs)). We note that the maximum strain is 3201, which is based on the strain curves depicted in Figures 9–10 (S8–sf 50%–(100%Cf. 0%Cs)).

Table 5: Group (3) Crack and Failure Load

Group	Column No	Mode of failure	(KN)	P failure	At Failure Axial Displacement (MM)	P Crack/P failure
	C8	Crushing	673	832	35.75	0.80
Group 3	C11	Crushing	560	895	29.46	0.62
	C12	Crushing	375	719	34.85	0.52

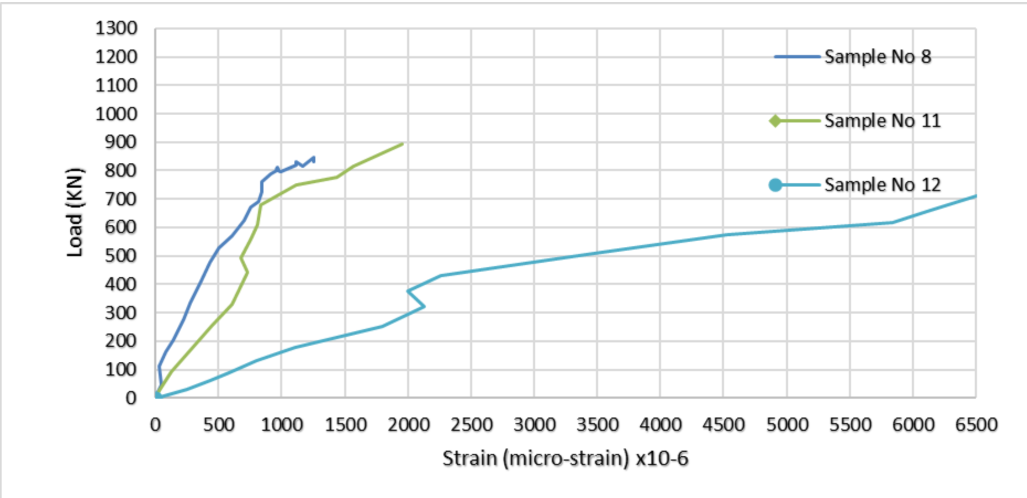

Fig 9: Strain for upper quarter part of the RFT bar

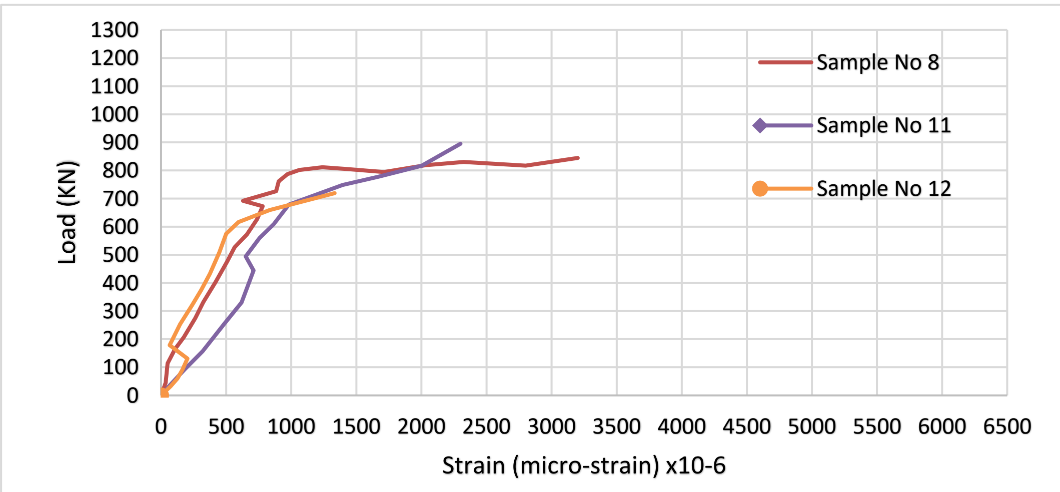

Fig 10: Strain for Mid part of the RFT bar

3.6 Group four

3.6.1 Crack Patterns and Failure Loads

All tested columns failed after the cracks spread downward to the loading region, with the majority of the cracks appearing at the top zones of the column. The first crack was either at the top of the column zone, and some finer cracks also appeared at the bottom. The tested columns in group 4's cracking patterns are displayed in Photo 10,11, and 12 following failures. The S4-sf 0%-(50%Cf. 50%Cs) Column At a load of roughly 791 KN, the first crack emerged, containing volume fraction (Vf) = 0%. As the load was increased, more cracks started to show through the column's upper quarter, and at a load of roughly 965 KN, the column failed.

Containing volume fraction (Vf) = 0%, the first crack (S5-sf 0%-(0%Cf. 100%Cs).) Emerged at a load of roughly 854 KN. More cracks started to show up as the load increased, passing the upper quarter of the column, and the column finally broke at a load of roughly 1211 KN. (0%-(100%Cf. 0%Cs)-S10-sf.) At a load of roughly 759 KN, the first crack emerged, containing volume fraction (Vf) = 50%. More cracks started to show up as the load increased; passing the upper quarter of the column, and the column finally broke at a load of roughly 956 KN. The three tested columns (C4, C5, and C10) had failure crack patterns that were almost identical in that concentrated loads led to cracking, with the majority propagating through the loading area experiments' top zone for the tested specimens in Group 4.

Photo 10: C10

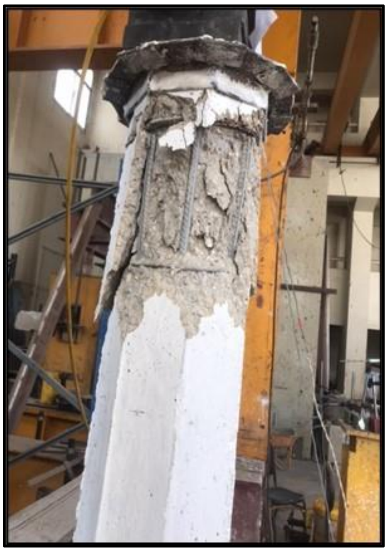

Photo 11: C4

Photo 12: C5

Table 6: Group (4) Crack and Failure Loads

Group	Column No	Mode of failure	Cracking Load (KN)	P failure	At Failure Axial Displacement (MM)	P Crack/P failure
	Sample 4	Crushing	791	965	35.75	Sample 4
Group 4	Sample 5	Crushing	854	1211.3	29.46	Sample 5
	Sample 10	Crushing	759	956	34.85	Sample 10

3.6.2 Measured Strain

The mid-height column's strain gauges were fastened to the primary steel bars that provided reinforcement. (S4-sf 0%-(50%Cf. 50%Cs)), (S5-sf 0%-(0%Cf.100%Cs)), and (S10-sf 0%-(100%Cf.0%Cs)) are the findings that indicate this. With regard to the three specimens, the relationship was linear. We note that the maximum strain in the upper quarter of the RFT bar is 1278, corresponding to (S10-sf 0%-(100%Cf.0%Cs)). We note that the maximum strain is 630, which is based on the strain curves depicted in Figures 11–12 (S5-sf 0%–(0%Cf.100%Cs)).

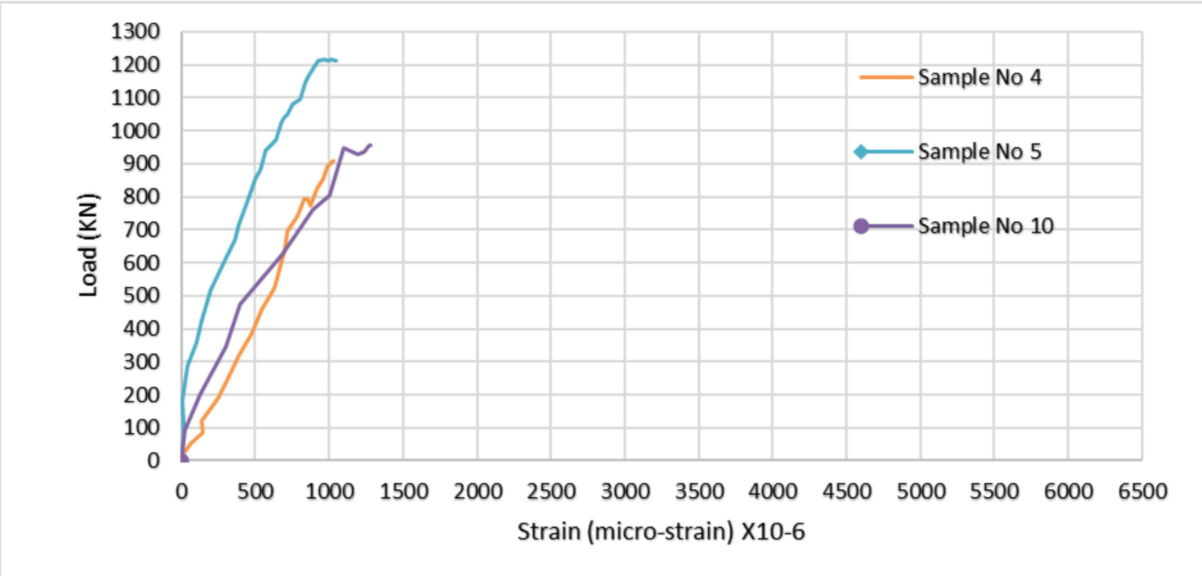

Fig 11: Strain for upper quarter part of the RFT bar

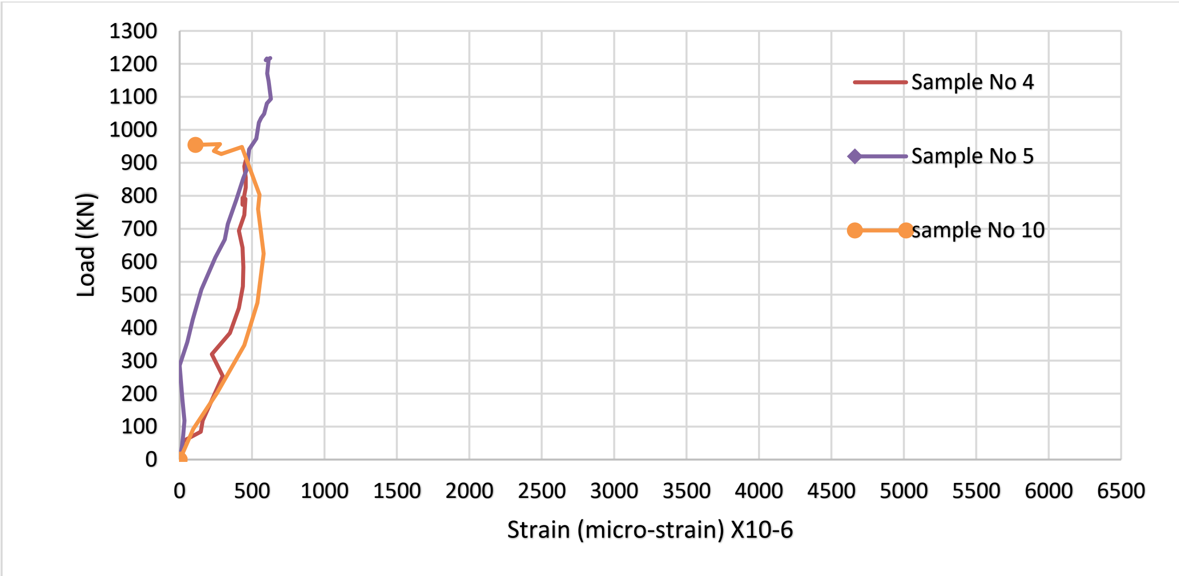

Fig 12: Strain for Mid part of the RFT bar

4 Conclusions

This manuscript discussed the effect of columns poured with seawater under eccentric loading. Also discussed the Mechanical characteristics such as compression strength for column poured with different type of water like sea, fresh, and mixed between sea and fresh also reinforced with different weight percentages of steel fiber (16%, 33%, and 50%) from the total Required RFT.

The main conclusions of this study are as follows.

1- The use of seawater at replacement ratios of 100% increased the 7-day- 28 days the cube test are showing some compressive strength 10%. However, the rate of compressive strength development of fresh water concrete was lower than that of sea water concrete. Whenever there is decreased in compressive strength by 15% by using (50% sea water +50% fresh water) in mixture using Jacking

2- Increasing the replacement ratio of seawater for the columns increased the number of cracks and decreased the spacing between them.

3- The use of Hybrid steel at replacement ratios of (16 ,33, and 50%) from the total Required RFT decreased the axial load 11%, 19% , and 22% respectively

4- All tested columns failed after the cracks spread downward to the loading region, with the majority of the cracks appearing at the top zones of the column. The first crack was either at the top of the column zone, and some finer cracks also appeared at the bottom.

In conclusion, we observe in this manuscript that using sea water in concrete column is applicable solution for compressive in column. sea water Should not have a short-term effect it is effect appears in long term so you should wait or use accelerated but on the other side using hybrid steel in concrete column have a bad effect on compression but it is effective on steel column corrosion

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