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Feasibility of Sea-Sand Sea-Water Concrete

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***Abstract*— This paper highlights the study of using sea-sand and sea-water in concrete construction in replacement of fresh water and river sand. Presence of chloride and sulphate in sea sand and sea water was compromised by using a combination of fly ash, blast furnace slag cement and chemical admixture, which in turn helps to increase the strength, workability and durability of concrete. In the recent years, due to the increasing scale of engineering construction and the increasing shortage of river sand resources, people have turned their attention to abundant sea sand resources. However, sea sand are not allowed to be used directly without any treatment because of the excessive chloride ions they contain. This project includes studies on the effects of using sea-sand and seawater as raw materials of concrete on the properties of the resulting concrete, including its workability, short and long-term strength as well as durability. From the existing research, the concrete made with sea-sand and seawater develops its early strength faster than ordinary concrete, but the former achieves a similar long-term strength to the latter. The combination of mineral admixtures for the concrete and reinforcement with anticorrosive measures can effectively solve the durability problem associated with the abundance of chloride ions in sea-sand seawater concrete (SSC).**

Keywords*— *Fly ash, blast furnace slag cement, chemical admixture, sea-sand seawater concrete.

I.INTRODUCTION

Consumption of tremendous amount of river sand and fresh water led to many serious environmental issues. The depletion of natural sand deposits and illegal sand mining is common concern these days. Extraction of river sand as fine aggregate has negative effects on river ecosystem, flood control, etc. Consumption of fresh water posses a greater challenge in many parts of the world due to water shortage. So it becomes necessary to search for an alternative solution. Around 71% of Earth's surface is covered with water and the oceans hold up to 96.5% of earth's water. So the use of sea-sand and sea-water as raw material of construction caught our interest. Desalting of sea-sand and sea water leads to extra construction cost. So in this project we adopted the usage of sea-sand and sea water without desalting and to study its effect on compressive strength of concrete. Direct use of sea-sand and sea-water in concrete productions is particularly implemented for coastal and marine projects.

II. OBJECTIVES

- To study the effects of using sea-sand and seawater without desalting as raw materials in concrete.
- To determine the compressive strength, flexural strength and splitting tensile strength of sea-sand sea-water concrete.
- To study the effect of blast furnace slag cement for the concrete to reduce corrosion due to the effect of sea sand and sea water.
- To study the effect of using epoxy coated reinforcing bars to meet the durability and corrosion problems associated with the abundance of chloride ions in sea-sand sea-water concrete.
- To determine the extent of corrosion in terms of mass loss in reinforcing bars under marine environment using accelerated corrosion test and weight loss analysis.

III. SCOPE

Demand for manufactured sand as fine aggregates for making concrete is increasing day by day as river sand cannot meet the rising demand of construction sector. Because of its limited supply, the cost of Natural River sand has sky rocketed. Under this circumstances use of manufactured sand becomes unavoidable. Therefore studying the differences in properties of both river and sea sand will give an idea whether sea sand can be altered in such a way that it can be used as a substitute for the depleting river sand. The discussions presented in this paper have clearly indicated that sea-sand and sea-water structures are most attractive in marine/coastal construction, where steel corrosion is a major concern and access to river sand and freshwater is limited while sea-sand and sea water are locally available.

- Most existing research has focused on the effect of chloride ions in sea-sand and seawater on the properties of the resulting concrete, but there has been very limited research on the effects of other chemicals on the short- and long-term properties of concrete, such as the effect of SO_4^{2-} in sea water on the performance of SSC. Much more research is needed in this area.
- More research is needed to gain a fuller understanding of this durability enhancement mechanism in SSC which has a much higher chloride ions content than ordinary concrete.
- Epoxy coated reinforcing bars, however, can deteriorate, even if only slowly, when exposed to severe environments. Very little research has been conducted on its long-term performance.

IV. MATERIALS AND METHODS

A. *Slag cement*

It is formed when granulated blast furnace slag is ground to suitable fines and blended with Portland cement. It has good resistance to chloride ion, improves drying shrinkage, water absorption, corrosion resistance thus improves durability of concrete. Bharathi Portland Slag cement was used in our work which about 40% slag blended in it.

TABLE 1. PROPERTIES OF BLAST FURNACE SLAG CEMENT

Properties	Result
Specific Gravity	2.95
Standard Consistency - % of water content	34 %
Initial setting time	40 minutes
Compressive Strength	40 N/mm²

B. *Fly ash*

Fly ash is a byproduct from thermal power plant and it is fine as well as spherical in shape. Due to its spherical shape it has greater workability and helps in reducing water requirement during casting. It reduces segregation and bleeding and lowers heat of hydration the colour varies according to it carbon contents from light to dark grey. To ensure better durable concrete, fly ash is an essential element which reduce the attack of sulphates and other components.

Cement reaction: $C_3S + H \longrightarrow C-S-H + Ca(OH)_2$

Pozzolanic reaction: $Ca(OH)_2 + S \longrightarrow C-S-H$

(Silicate from Fly ash)

The initial setting time of fly ash is low, with increment of age the hydration degree of cement improves and pozzolonic activity of fly ash appear.

TABLE II. PROPERTIES OF FLYASH

Properties	Results
Specific Gravity	2.5
Initial setting time	170 minutes
Final setting time	240 minutes

C. *Coarse aggregate*

Coarse aggregate of 65% and 35% of 20 mm and 12.5 mm respectively were used. Testing of coarse aggregate was done as per IS: 383-1970.

TABLE III . PROPERTIES OF COARSE AGGREGATE

Properties	Results
Specific Gravity	2.71
Percentage water absorption	0.806 %
Percentage air voids	45.35 %
Bulk density of compacted aggregate	1.73 kg/L
Bulk density of loosely packed aggregate	1.53 kg/L

D. *Fine aggregate*

In this project sea sand and M-sand are used as fine aggregate .As per IS383-1970, T-4, the fine aggregate can be graded into 4 zones depending upon the %finer retained in each sieve. Graph is plotted with sieve opening to log scale on X-axis and %finer on Y-axis. The obtained curve is called Grading curve

TABLE IV. COMPARISON OF PROPERTIES OF SEA SAND AND M-SAND

Properties	Sea Sand	M Sand
Specific gravity	2.725	2.755
Water absorption	1.008 %	1.63 %
Bulk density of compacted aggregate	1.659 kg/L	1.685 kg/L
Bulk density of loosely packed aggregate	1.517	1.54
Percentage air voids	39.11 %	42.1%
Fineness Modulus	2.13	2.94
Zone of Gradation	Zone III	Zone II

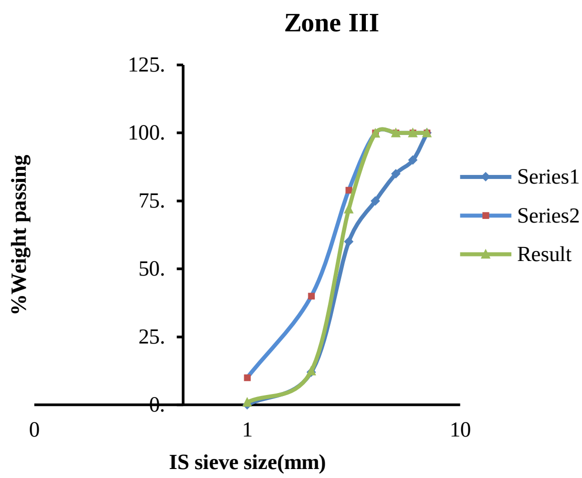

Fig 1. Grading Curve of Sea Sand

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TABLE V. TABULATED RESULT OF SIEVE ANALYSIS (SEA-SAND)

Is sieve size	Weight Retained (gm)	Cumulative % Weight Retained (gm)	Cumulative % Weight Retained (gm)	Cumulative % Weight Passing
10mm	0	0	0	100.00
4.75mm	0	0	0	100.00
2.36mm	0	0	0	100.00
1.18mm	1	1	0.108	99.90
600µ	277	278	28.024	71.98
300µ	590	868	87.5	12.50
150µ	115	983	99.092	0.91
Lower than 150	9	992	-	
Total	992		214.71	

Fineness modulus of fine aggregate (sea sand) was found to be 2.13 which lies between 2 and 3.5. The collected sea sand lies in Zone III shown in "fig.1" (Grading is done as per IS383: 1970, table 4).

TABLE VI. TABULATED RESULTS OF SIEVE ANALYSIS (M-SAND)

Is sieve size	Weight Retained (gm)	Cumulative % Weight Retained (gm)	Cumulative % Weight Retained (gm)	Cumulative % Weight Passing
10mm	0	0	0	100.00
4.75mm	0.145	0.145	14.5	85.50
2.36mm	0.297	0.442	44.2	55.80
1.18mm	0.197	0.639	63.9	36.10
600µ	0.156	0.795	79.5	20.50
300µ	0.121	0.916	91.6	8.40
150µ	0.084	1	-	
Lower than 150	1	1	293.7	
Total	0		0	00.00

Fineness modulus of fine aggregate (M sand) was found to be 2.94, which lies between 2 and 3.5. The collected M sand lies in Zone II shown in "fig.2" (Grading is done as per IS383: 1970, table 4).

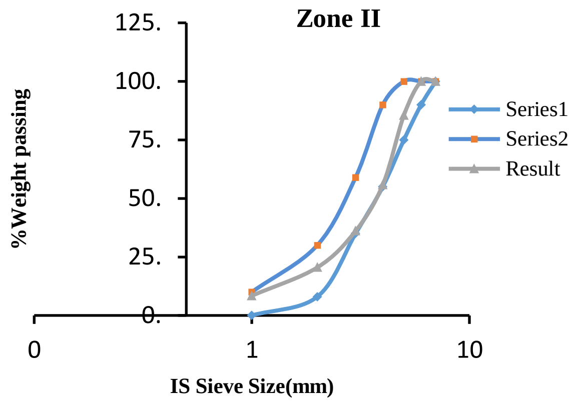

Fig 2. Grading Curve of M-Sand

E. Sea-water

Sea water was collected from Vypin, Kerala. Test was conducted as per IS305(P)16-1984 RA2017.

TABLE VII. CHEMICAL PROPERTIES OF SEA WATER

Chemical Characteristics	Result
pH	8.84
Chloride	25254 mg/L
Sulphate	1126.03 mg/L
Total Dissolved Solids	45500 mg/L
Total Hardness as $CaCO_3$	20900 mg/L

F. Super-plasticizer

These are chemical admixtures which are used to reduce the water content and improve workability. By reducing water to cement ratio the early strength is attained much faster. It also helps in reducing segregation and bleeding. The chemical admixture that we used in **MasterGlenium Sky ACE 301T** it is free from chloride and low alkali and is compact-able with all types of cement. Improves engineering properties compared to traditional plasticizer such as ultimate compressive strength, flexural strength, reduce shrinkage and improve durability.

TABLE VIII. PROPERTIES OF SUPER PLASTICIZER

Parameter	Specifications (As Per IS 9103)	Result
Physical State	Reddish Brown Liquid	Reddish Brown Liquid
Chemical Name Of Active Ingredient	Polycarboxylate Polymers	Polycarboxylate Polymers
pH	Min 6	7.02
Specific gravity	1.110 ± 0.01	1.1
Chloride ion content	Max 0.2	0.0072%
Relative density at 25°C	1.110 ± 0.01	1.110

V. CASTING AND COMBINATION OF SPECIMEN

Casting is the process of mixing the required amount of materials (according to the mix design) together and placing them in a standard mould and allowing to dry for about 48 hours and bringing back the concrete for the process of curing. Preparation of mixes with following combinations:

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1) Concrete mix consist of blast furnace slag cement, fly ash, seawater, M-sand and superplazticers.
2) Concrete mix consist of blast furnace slag cement, fly ash, sea sand, sea water and superplazticers.
3) Concrete mix consist of blast furnace slag cement, fly ash, normal water, sea sand and superplazticers.
4) Concrete mix consist of M-sand, normal water, blast furnace slag cement and superplazticers.

Casting of specimens for the above mentioned mixes. Total 36 specimens are casted. 9 cubes for each above mentioned mixes.

VI. TRIAL MIXES AND RESULTS

Batches are done for varying proportion of superplazticers and percentage water reduction with or without fly ash. The workability of the Trial Mixes were measured by determining slump value. The mix shall be carefully noted for freedom from segregation and bleeding and its finishing properties. The measured workability of Trial Mix No.I is different from the stipulated value, therefore water and admixture content were adjusted suitably.

With this adjustment, the mix proportion shall be recalculated keeping the water-cement ratio at the pre-selected value, which will comprise Trial Mix No.3. and Trial Mixes No.5. We're made with the varying proportion of superplazticers and percentage water reduction. Also Trial No. 2 and Trial No. 4 were made with adding fly ash. There by we found that initial setting period of concrete was increased to 48 hours. From the workability and average 7 day compressive strength for different trial batches, we inferred that Trial No.5 gives the suitable proportion of mixes.

TABLE IX . TRIAL MIXES PREPARED

Combination	**% Water reduction**	**%Super plasticizer**	**Slump value (mm)**	**Average 7 day compressive strength (N/mm²)**
1) Sea sand + Sea water	25	0.6	121	49.33
2) Sea sand + Sea water + Flyash	25	0.6	110	38.97
3) Sea sand + Normal water	20	0.5	88	51.11
4) Sea sand+ Normal water + Flyash	20	0.5	79	40.53
5) Sea sand +normal water +Flyash	20	0.55	97	48.62

VII. MIX DESIGN

Mix design is based on the guidelines given in Indian standard IS 10262:2009 for concrete mix proportioning. Here mix design for M sand and Sea-sand are separately done based on zone of fine aggregate as described on table 3 of IS 10262 : 2009. Four mix design were done and specimens are casted by calculating weight of raw materials which are cement, M-sand, sea-sand, fly ash and coarse aggregate. Also quantity of water and superplazticers are calculated.

TABLE X. QUANTITY OF MATERIALS REQUIRED FOR 1 m³ OF CONCRETE

Quantity	**M Sand And Seawater**	**M-Sand And Normal Water**	**Sea-Sand And Normal Water**	**Sea-Sand And Seawater**
Grade	M 40	M 40	M 40	M 40
Volume of Concrete	1 m³	1 m³	1 m³	1 m³
Weight of cement	340.59 kg	425.73 kg	340.59 kg	340.59 kg
Weight of flyash	85.15 kg	0 kg	85.15 kg	85.15 kg
Weight of fine aggregate	675.30 kg	680.35 kg	628.85 kg	628.85 kg
Weight of coarse aggregate	1220.64 kg	1229.77 kg	1258.32 kg	1258.32 kg
Water – Cement ratio	0.36	0.36	0.36	0.36
Quantity of water used	153.26 L	153.26 L	153.26 L	153.26 L
Quantity of super plasticizer	2.13 L	2.13 L	2.13 L	2.13 L

VIII. WORKABILITY TEST

We have done slump test for determining the workability of different combinations were mixed with 20 percent water reduction and 0.55 percent plasticizer. Before placing the mix into the slump cone 30min activation time is provided for activation of superplasticizer.

TABLE XI. SLUMP VALUES OF DIFFERENT COMBINATIONS

Combination of Specimen	**Slump Value (mm)**
M sand and Normal water	97
M sand and seawater	92
Sea sand and Normal water	80
Sea sand and seawater	88

IX. STRENGTH TEST

X.

A. Compressive strength test (7 days, 14 days, and 28 days)

Average compressive load for 7, 14, and 28 days for different combinations were observed and calculate average compressive strength in N/mm^2.

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TABLE XII. OBSERVATION OF 7, 14 AND 28 DAYS COMPRESSIVE STRENGTH

Combination of Specimen	Average 7 day Compressive Strength (N/mm²)	Average 14 day Compressive Strength (N/mm²)	Average 28 day Compressive Strength (N/mm²)
M sand and Normal water	41.333	42.22	44
M sand and seawater	46.666	46.66	51.11
Sea sand and Normal water	46.666	48.44	53.33
Sea sand and seawater	44.444	47.55	49.77

B. Splitting tensile strength test (28 days)

TABLE XIII. OBSERVATION OF SPLITTING TENSILE STRENGTH

Combination of Specimen	Average Maximum Load (kN)	Average Splitting Tensile Strength (N/mm²)
M sand and Normal water	310	4.38
M sand and seawater	280	3.96
Sea sand and Normal water	325	4.59
Sea sand and seawater	300	4.24

C. Flexural strength test (28 days)

TABLE XIV. OBSERVATION OF FLEXURAL STRENGTH

Combination of Specimen	Maximum Load (kN)	Flexural Strength (N/mm²)
M sand and Normal water	53	21.2
M sand and seawater	45	18
Sea sand and Normal water	33	13.2
Sea sand and seawater	35	14

XI. ACCELERATED CORROSION TEST

Corrosion is a very slow process, electrochemical techniques have long been used to reduce the time of rebar de-passivation to a desirable time-scale. One of which is Impressed Voltage Test (IVT). In this method, rapid corrosion is facilitated by raising the potential difference between two electrochemical sites. The amount of mass consumed is directly related to the flow of electrical energy which can be modelled by Faraday's law.

A. Principle

The principle of this technique is that the region near or below the water line becomes anodic due to Cl^- penetration; and corrosion of this area is driven by the cathode portion of the reinforcing steel, which is in the air.

B. Experimental Setup for Impressed voltage test

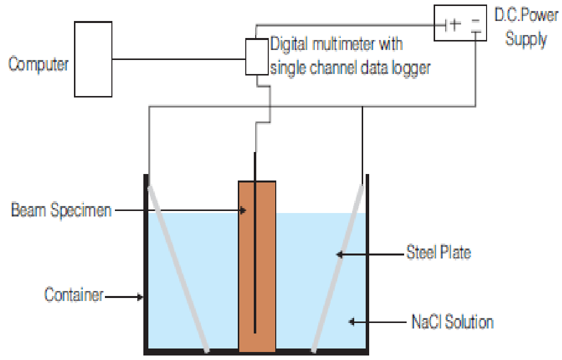

Fig.3. Experimental set up of IVT

It consists of a DC power supply, two stainless steel plates, a data logger, test specimen with embedded reinforcement steel and the container containing the required dosage of NaCl solution. The experiment includes 4 cylinders each from the early mentioned combination. Sodium Chloride salt was used to prepare the 5% salt water concentration by weight. These cylinders with embedded steel bar are used for the accelerated corrosion test.

The steel bar of the specimen is connected to the positive terminal and the stainless steel plates are connected to the negative terminal of the DC power source. The corrosion process is initiated by applying a constant voltage (12V) to the system. And later it increases to 28V. The current response is continuously monitored and recorded. In addition the specimens are daily inspected visually for the onset of cracks .The accelerated corrosion test is terminated after cracking of the specimen when the rate of increase of corrosion current with time was negligible.

Fig.4. Laboratory setup of accelerated corrosion test

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C. Time – Current Observations Of Different Mixes

TABLE XV. CURRENT PASSED AT DIFFERENT OBSERVATION PERIODS

Time of Observation	**Current Passed (mA)**			
	M Sand and Normal Water	**Sea Sand and Normal Water**	**Sea Sand and Sea Water**	**M Sand and Seawater**
Day 1	0	0.3	0.8	0.38
Day 4	0	0.29	0.8	0.38
Day 8	0	0.33	0.83	0.39
Day 12	0	0.27	0.85	0.39
Day 16	0	0.28	0.87	0.41
Day 22	0	0.32	0.88	0.40
Day 26	0	0.25	0.9	0.42

D. Mass Loss Analysis

After the cylinders specimens are corroded and the measurement of half-cell potential and free chloride ion content are taken, the beam specimens are jack hammered to remove the corroded longitudinal steel bars. The corroded bars are cleaned with a wire brush to ensure that they are free of any adhering concrete or corrosion products. Cleaning of the corroded steel specimens are carried out according to the procedure stated in ASTM G 1-03 and for determination of mass loss.

E. Determination of Percentage of Corrosion Damage

TABLE XVI. OBSERVATION OF MASS LOSS

Combination	**Initial mass (kg)**	**Final mass (kg)**	**% mass loss**
M sand and Normal water	0.161	0.161	**0**
M sand and seawater	0.161	0.160	0.62
Sea sand and Normal water	0.161	0.161	0
Sea sand and seawater	0.161	0.161	0

Fig.5. Reinforced bars after ACT

XII. RESULT AND DISCUSSION

A. Workability

On applying 20 percent water reduction and 0.55 percent of plasticizer for different combinations we got a slump value with in the range 100-70 mm. All the combinations gave better workability.

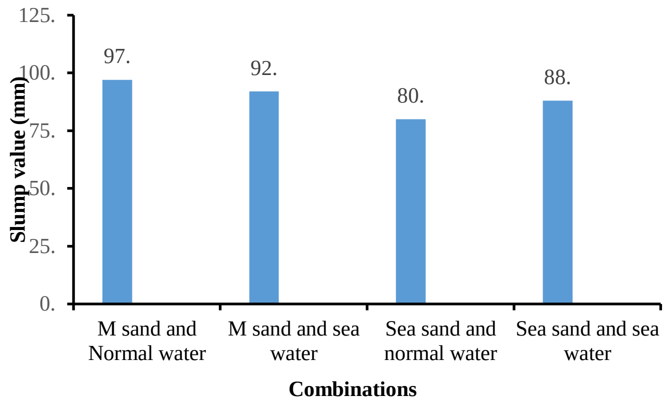

Fig.6. Comparison of workability

B. Compressive Strength of Cubes

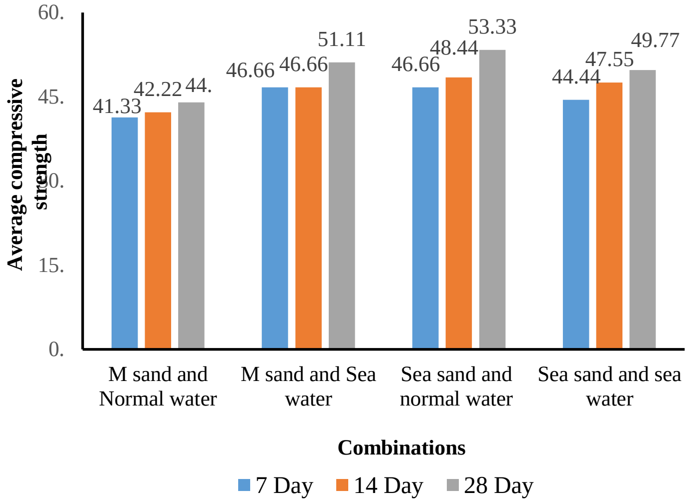

Fig.7. Comparison of compressive strength in N/mm^2

From the obtained data it was observed that M sand and sea water combination and sea sand and normal water combination showed highest 7th day strength. The expected 7 day strength was 32.16 N/mm^2. While sea sand and normal water combination showed highest 28th day strength. All the combinations showed high initial strength then there was a gradual increase in strength.

C. Splitting tensile strength of cylinder

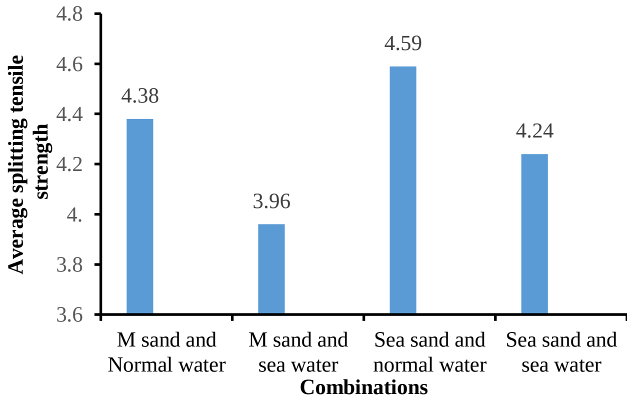

Fig.8. Comparison of splitting tensile strength in N/mm^2

As per IS 456-2000, the obtained splitting tensile strength shall not be less than $0.1*f_{ck}= 0.1*40 = 4$ N/mm^2. The value obtained from the experiment for all the type of mix is greater than 4 N/mm^{2}except the m sand and sea water combination which displayed 3.96 N/mm^2. The flexural strength of sea-sand and normal water mix showed highest strength when compared to other mixes.

D. Flexural strength of beam

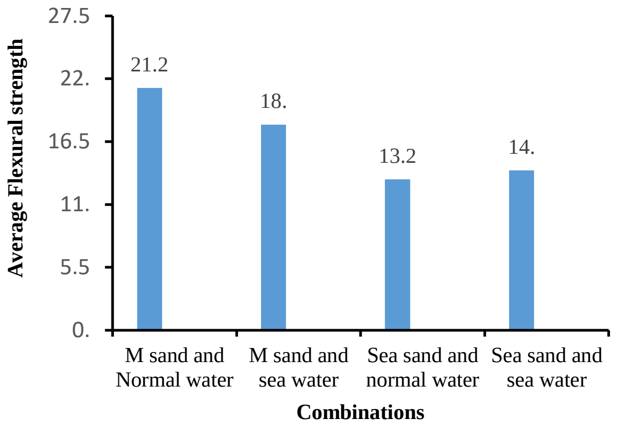

Fig.9. Comparison of flexural strength in N/mm^2

As per IS 456-2000, Flexural strength $f_b = 0.7\sqrt{fck} = 0.7*\sqrt{40} = 4.42$ N/mm^2.The value obtained from the experiment for various mix comes above 4.42N/mm^2. In this M sand and Normal water combination showed highest strength.

E. Acceleration corrosion (Current - Duration Graph)

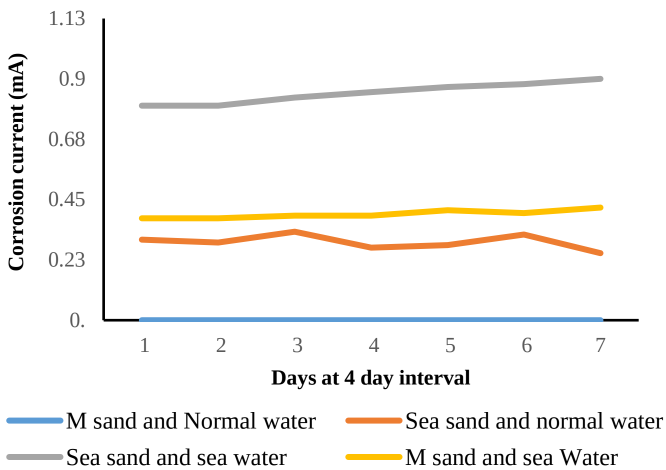

Fig.10. Comparison of current passed through each specimen

From the current Vs duration graph it was noted that by using epoxy coated reinforcement current passage is minimum. In the different combinations tested M sand and normal water combination showed zero current transfer during the whole days of test. While the sea sand and normal water combination showed a fluctuating graph.

XIII. CONCLUSION

The benefits of using sea water and sea sand in concrete to replace fresh water and river sand has been evaluated by conducting strength test. Blast furnace slag cement and epoxy coated reinforcement has been used to solve the durability problem associated with the chloride content in sea sand and sea water. Accelerated corrosion test has been conducted to determine the effect of using epoxy coated reinforcement in concrete to reduce corrosion rate. Sea sand and sea water didn't affect the workability of our different concrete mixes used. Due to the combination of chlorides with slag cement attainment of high early strength was noted in our experiment. All the combinations attained the design strength initially itself and it was noted that there was only a gradual increase in strength with passage of time. In compressive strength test sea sand and normal water combination expressed the highest final day compressive strength. In splitting tensile strength sea sand and normal water combination attained maximum strength. In flexural beam test M sand and normal water combination gives the maximum strength. Plasticizer helped in attaining strength with reduction in water addition during the mixing of concrete. From accelerated corrosion test we came to conclusion that in all combinations the passage of current was almost nil and was safe using all the combinations in construction mainly in marine areas. By the implementation of this method in construction large amount of construction materials used can be replaced by low rate economic materials with better strength and durability.

XIII. REFERENCES

[1] Adel Younis, Usama Ebead, Prannoy Suraneni, Antonio Nanni (2018) : Fresh and hardened properties of seawater-mixed concrete, Construction and Building Materials, pp. 1- 18.

[2] B.Sathish Kumar, P.Samuthirapandiyan, K.Sabari Rajan, A. Subalakshmi (2018) : Effect of sea water and strength of concrete, International Research Journal of Engineering and Technology, Vol.5, Issue 4, pp.1195- 1199.

[3] R.L. Henry (1963) : The effect of salt in concrete on compressive strength, water vapour transmission and corrosion of reinforcing steel, ASTM, pp. 1046–1078.

[4] Gidion Turuallo, Harun Mallisa (2018) : Using cementitious materials such as fly ash to replace a part of cement in producing high strength concrete in hot weather, IOP Conference Series : Materials Science and Engineering, pp. 1-5 .

[5] Gracemodupeolaamusan and Festusadeyemiolutoge (2014) : The effect of seawater on shrinkage properties of concrete, International Journal of Research in Engineering & Technology, Vol 2,Issue10, pp.1 -12.

[6] J.H Potgieter, D.J.Delport, S.Verryn and S.S Potgieter-Vermaak (2011) : Chloride – binding effect of blast furnace slag in cement pastes containing added chlorides, Research Article, pp.108-114.

[7] Jianzhuang Xiao, Chengbing Qiang,Antonio Nanni, Kaijian Zhang (2017) : Use of sea-sand and seawater in concrete construction:Current status and future opportunities, *Construction and Building Materials*, Vol.155, August 2017, pp. 1101–1111.

[8] K.J. Kucche, S.S. Jamkar, P.A. Sadgir (2015) :Quality of water for making concrete: a review of literature, International Journal of Science and Research, Publ. 5 (1), pp. 1–10.

[9] Md. Moinul Islam, M.d Saiful Islam, Md. Al-Amin and Md. Mydul Islam (2012) : Suitability of sea water on curing and compressive strength of structural concrete, Journal of Civil Engineering, Vol.40(1), pp.37-45.

[10] Michael A. Taylor, Adam Kuwairi (1978) : Effects of ocean salts on the compressive strength of concrete, Cement and Concrete Research , Vol. 8, pp. 491-500.

[11] Mohamed Anwar, Mahmoud Roushdi (2013) : Improved concrete properties to resist the saline water using environmental by-product, National Water Research Centre, Elsevier, pp .30-38.

[12] Mohammad Abushad, Misbah Danish Sabri (2017): Comparative study of concrete with flyash replacement by cement, International Research Journal of Engineering and Technology, Vol. 4, Issue 7, pp.2627-2630.

[13] N. Otsuki, T. Saito, Y. Tadokoro (2012) : Possibility of seawater as mixing water in concrete, J. Civ. Eng, Arch 6 (10) , pp.1273–1279.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 08, August-2019

[14] Olutoge, F. Adeyemi and Amusan, G.Modupeola (2014) : The effect of sea water on compressive strength of concrete, International Journal of Engineering Science Invention, Vol 2, Issue 7, pp. 23-31.

[15] S.D. Ramaswamy, M.A. Aziz, C.K. Murthy (1982) : Sea dredged sand for concrete, extending aggregate resources, ASTM Int. 774, pp.167–177.

[16] Takahiro Nishida, Ph.D.; Nobuaki Otsuki, Ph.D., M.ASCE; Hiroki Ohara, Zoulkanel Moussa Garba-Say; and Tomohiro Nagata (2013) : Some consideration for applicability of seawater as mixing water in concrete, American Society of Civil Engineers, pp. B4014004-1 – B401400-7.

[17] Y.L. Li , X.L. Zhao, R.K. Singh Raman (2018) : Mechanical properties of seawater and sea sand concrete-filled FRP tubes in artificial seawater, *Construction and Building Materials*, Vol.191, pp.977-993.

[18] Y.L. Lia, X.L. Zhaoa, R.K. Singh Ramanb, X. Yua (2018) : Axial compression tests on seawater and sea sand concrete-filled double-skin stainless steel circular tubes, *Engineering Structures*, Vol.176, 2018, pp. 426-438.

[19] Z.H.Yang, Z.J. Bi, W.J. Chen, Y. Cao,Y.Q. Jiang, G. Yang, Y. Jiang (2009) : Summarization on influence of water to concrete performance, pp.115–116.