Application of Seawater and Sea Sand to Develop Geopolymer Composites

Salmabanu Luhar, Ismail Luhar

Abstract*: Worldwide, concrete is predominantly used as a versatile building material with its highest consumption on the earth. Nevertheless, its exigency accelerates day by day exhausting restricted natural resources in its manufacturing. Consequently, in order to prevent the degradation of these natural confined aggregates resources, it's highly essential to employ other alternative profuse materials in their place. On the one hand, the sea Sand is existing in huge quantity below seas and oceans while on the other hand, restricted river Sand resources are being quarried haphazardly and hence reaching to their end. What's more, to flashlights on, the production of every ton of cement contributes to the emission of an almost equal quantity of CO_2 with high energy consumption. Also, it is worth mentioning that freshwater resources are in the limited quantity and, therefore, mankind is not getting sufficient fresh water even to drink in some corners of the world. In present experimental investigations, all the above burning dilemmas are kept in mind and hence, the sea Sand is used as an alternative to river Sand whereas sea water is used instead of distilled water for laboratory investigations on the properties of Geopolymer concrete and mortar in the total absence of Ordinary Portland Cement. The results demonstrated that the sea sand and seawater have no doubt affected the strength of Geopolymer concrete and mortar but just insignificantly.

***Keywords:* Compressive Strength, Geopolymer Composite, Alkaline Liquid, Sea Sand, Sea Water, Split Tensile Strength, Flexural Strength.**

I. INTRODUCTION

In this Modern epoch, the boom in global population has escalated the demand for more housings and infrastructures which in turn, amplified the exigency of prerequisite materials like restricted natural rocks, minerals and water resources especially fresh water to produce cement and concrete to construct structures. The pushy global infrastructural development necessitates more manufacturing of mortar and concrete which eventually boosted the production of Ordinary Portland cement (OPC) as an essential binder. Indian demand for OPC is expected to accelerate to 550-600 million tons per annum by 2025! [1-4]. For the most part, Indian housing sector alone accounts for about 67% of entire cement consumption! [5-8]. However, there are scores of challenges in the pathway of the present production process for OPC. One key concern is its detrimental environmental impact. Each ton of OPC production is answerable to equal quantity of Carbon Dioxide emissions into the atmosphere [9-12], and that is the core reason for 7% of global CO_2 emissions through this blameworthy process [13-16].

More to add, another chief concern with conventional OPC-based mortar is its durability in adverse conditions. Studies have demonstrated that OPC provides adequate strength, but is susceptible to depreciate under aggressive environmental conditions especially when subjected to acidic surroundings. Conventional OPC-mortar also has long setting and hardening times and can withstand a load subsequent to curing for 7-10 days, which is a long time in modern time that demands swift construction. What is more, huge quantities of water are necessitated for the curing of mortar. All the above-mentioned concerns have directed to an urgent call for a sustainable and eco-friendly mortar that performs well in adverse surroundings.

India is one of a major rice producing countries. The husk generated by milling the rice is generally employed as a boiler fuel for processing the paddy, producing energy through direct combustion and gasification. This produces about 20 million tons of rice husk ash each year, which poses a significant environmental threat to the land on which it is dumped. Thus, methods for making commercial use of this rice husk ash are attracting considerable attention.

Nevertheless, sea sand is available in ample quantity in coastal areas. In addition, In coastal areas, sand is available in meagre quantity, and its transportation cost is enormous. Past researchers found that sea sand cannot be used in construction as fine aggregate due to salt and chloride present with it which affects the hydration process in OPC - Concrete. The situation is however divergent in case of Geopolymer concrete. Since the Geopolymerization process takes place in this case, hence salt and chloride content are not anticipated to have a detrimental effect. The fly ash is also expected to mitigate the harmful effects of the chloride present in sea sand [1].

United Nations (UN) and World Metrological Organization (WMO) have predicted that 5 billion people will be in short of even drinking water. Freshwater resources are also limited in quantity. Worldly people are not getting sufficient fresh water even to drink in some of the parts of the world.

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This is also a great issue for lives on the planet. It is also said that in 2025 half of humanity will live in the areas where fresh water is not enough [17]. One solution to this predicament is to utilize sea water to substitute fresh water in concrete casting. Seawater is expected to be less harmful to the Geopolymer composites.

This paper reports the findings and analysis of compressive strength tests on Geopolymer mortar with 100% replacement of cement with fly ash. Additionally, the fly ash was partially replaced by rice husk ash (0%, 10%, 20%, and 30% replacement) to observe the effect on compressive strength of Geopolymer mortar. Each set of replacements was formed using four combinations of sand and water, namely normal sand, sea sand, normal water, and seawater, to investigate the variation in compressive strength in the geopolymer mortar. Also, this research paper presents the experimental findings for mechanical properties such as split tensile strength and flexural strength for Fly ash based Geopolymer concrete manufactured with sea water and sea Sand as well as controlled Geopolymer concrete.

II. PREVIOUS RESEARCH

The literature available on the effects of seawater and sea sand on cement composites is present in Table-I. Very Few studies were available on seawater and sea sand used to produce geopolymer composites. Therefore, the current research focuses on a comparative study of control geopolymer composite fabricated with distilled water and river sand and geopolymer composites produced by using seawater and sea sand.

III. RESEARCH METHODOLOGY

This research based on the experimental study. Comparative analysis was conducted between geopolymer composites mixtures made with seawater and sea sand while control geopolymer composites mixtures made with distilled water and river sand.

The entire study was divided into two phases: first, investigation of effect of fly ash amount and alkaline liquid ratio, sea sand and seawater compressive strength of geopolymer composites; second, determine the flexural and split tensile strength of geopolymer concrete made with seawater and sea sand and compare the results with control geopolymer concrete made with distilled water and river sand. Fig. 1 illustration of research methodology.

IV. EXPERIMENTAL INVESTIGATION

A. Materials Characterization, Mix Proportioning and method

Source Material

Fly ash was selected as the primary source material because of its high silica and alumina content, which is favorable for the process of geopolymerization. The secondary source material was chosen to be rice husk ash (RHA), as we wish to investigate the impact of replacing fly ash with RHA.

Alkaline Liquid

Sodium hydroxide (NaOH) in flakes form of sodium hydroxide with 98% purity was used which was dissolved in water to prepare the solution with desired Molarity (14M). Sodium silicate (Na_2SiO_3), Glass form was used as the alkaline activator. The liquid was prepared 24 h prior and kept undisturbed until casting. The alkaline liquid prepared by mixing of Sodium hydroxide solution and Sodium silicate solution.

Aggregate

Locally available River sand having 4.75 mm size and sea sand were used as fine aggregates. Properties of river sand and sea sand were shown in Table-II. Locally available crushed basalt was used as coarse aggregates having 20 mm and 10mm sizes. Properties of aggregates were shown in Table-III.

Table- II:Properties of Rice husk ash*

Sr. No.	Test	Unit	Rice husk ash Properties
1	**Colour**	--	Grey
2	Loss on Ignition	%	5.96
3	SiO_2	%	86.32
4	Al_2O_3	%	0.35
5	MgO	%	0.51
6	SO_3	%	0.42
7	C	%	5.58
8	CaO	%	0.62
9	Fe_2O_3		0.24

*Provided by manufacturer

Table- III: Properties of Aggregates

Sr.No	Properties	River Sand	Sea Sand	Coarse aggregate
1	Specific gravity	2.6	2.3	2.67
2	Water absorption (%)	0.8	0.95	0.5
3	Moisture content (%)	0.15	0.21	Nil
4	Fineness modulus	2.5	2.6	--
5	Zone	II	II	--

V. TESTING METHOD

Compressive strength was measured as per IS: 516-1959 and IS: 2250- 1981 [18]. Cube specimens having size 100mm X 100mm X 100mm and 50mm X 50mm X 50mm of geopolymer concrete and geopolymer mortar, respectively. Cylindrical specimens 150mm diameter and 300 mm height were used for split tensile strength whereas 100mmX 100mm X500mm size beams were used for flexural strength test as per IS-516-1959[19]. Test details are given in Table-IV.

Table- IV: Test details

Sr. No	Test Performed	IS code
1	Compressive strength Test	a. Concrete-IS: 516-1959 b. Mortar-IS: 2250- 1981
2	Flexural Strength Test	IS: 516-1959
3	Split tensile strength test	IS 5816: 1999

VI. MIX PROPORTIONING OF GEOPOLYMER COMPOSITES

Mix Proportioning of geopolymer mortar and geopolymer concrete are shown in Tables V and VI, respectively.
For each of the Geopolymer mortar mixes (G-1, G-2, G-3, and G-4), different proportions of fly ash were replaced by RHA. In the following, G1/10 denotes the G1 mortar with 10% replacement of fly ash by RHA, and so on. For each of the geopolymer concrete mixes (GC-1, GC-2, GC-3 and GC-4), fly ash was used as source material.

The following constituents for mix design were determined based on the results of the parameters:

Rice husk based Geopolymer Mortar [20]

The ratio of alkaline liquid to fly ash by mass: 0.45
sodium silicate to sodium hydroxide ratio: 2.5
The concentration of sodium hydroxide solution: 14M
Admixture dosage: 1%
Additional water content: 5%
Curing temperature: 60°C
Curing time: 24 h
Rest period: 0 days
Fly ash-based Geopolymer Concrete
The ratio of alkaline liquid to fly ash by mass: 0.4
Sodium silicate to sodium hydroxide the ratio: 2.5
The concentration of sodium hydroxide solution: 14 M
Admixture dosage: 2%
Additional water content: 5%
Curing temperature: 65°C, 90°C
Curing time: 48 h
Rest period: 1 day,

VII. RESULT ANALYSIS AND DISCUSSION

A. Compressive Strength Test

As described above, 7 days and 28-day compressive strength tests were conducted.

From Figs. 2 and 3, it is apparent that 10% replacement of fly ash with RHA gives the maximum 7-day compressive strength for all specimens. The results are present for all combinations of sea sand, river sand, sea water, and normal water.

From these, it is clear that, though the 7 days compressive strength decreases in the presence of salinity/impurity (in the form of sea water, sea sand, or both), these mixes are stronger than the conventional H1-type OPC mortar after 28 days, i.e. 10 MPa in all cases (except for the 30% replacement of all four combinations). This confirms that as far as early and higher compressive strength gains are concerned, geopolymer mortar is superior to conventional OPC mortar.

Fig.2 shows the variation in compressive strength with sand and water type for various replacement percentages of fly ash with RHA. Similarly, Fig.3 tabulate the 28-day compressive strength results, confirming that 10% replacement of fly ash with RHA gives the maximum 28-day compressive strength for all specimens.

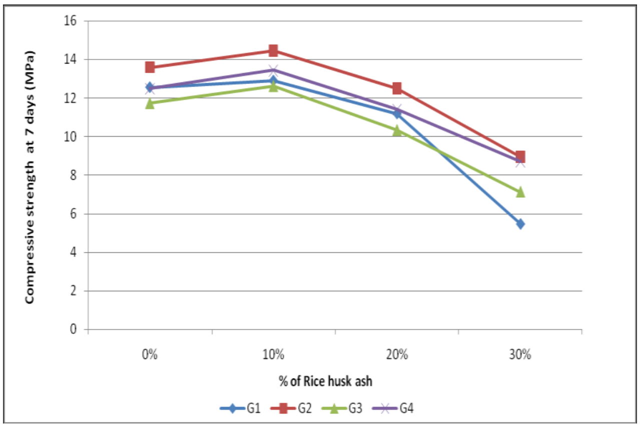


Fig.2. Seven day compressive strength variation

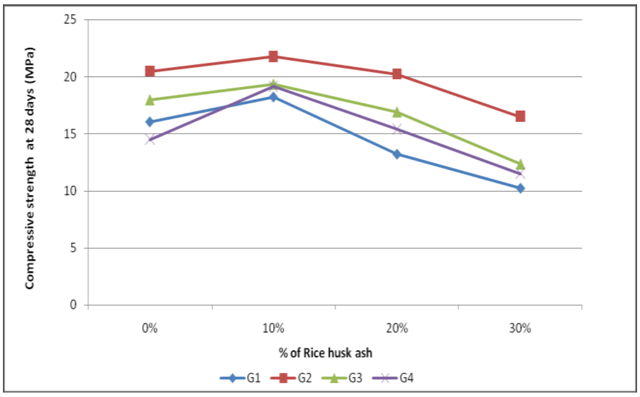
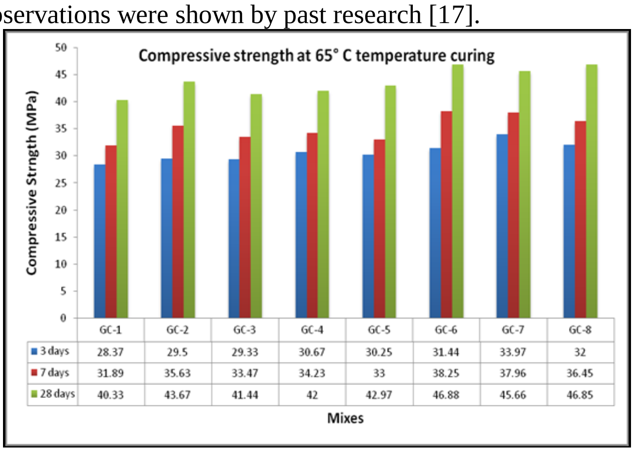


Fig.3. Twenty-eight-day compressive strength variation

Figs.4 and 5 shows a graphical representation of compressive strength for all mixes of fly ash based geopolymer concrete at 3, 7 and 28 days. Figures show that an increase in compressive strength with the increase in the age of the geopolymer concrete at 65°C and 90°C curing temperature for all mixes. A significant change in compressive strength was observed in geopolymer composites fabricated with seawater and sea sand. The compressive strength of geopolymer concrete increase as the curing temperature increased was observed. Similar observations were shown by past research [17].



	GC-1	GC-2	GC-3	GC-4	GC-5	GC-6	GC-7	GC-8
3 days	28.37	29.5	29.33	30.67	30.25	31.44	33.97	32
7 days	31.89	35.63	33.47	34.23	33	38.25	37.96	36.45
28 days	40.33	43.67	41.44	42	42.97	46.88	45.66	46.85

Fig.4 Compressive strength of geopolymer concrete at 65°C curing temperature

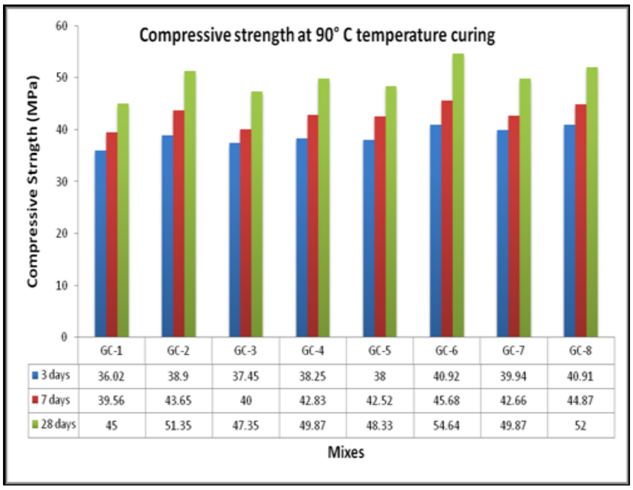


Fig.5 Compressive strength of geopolymer concrete at 90 °C curing temperature

B. Split Tensile Strength Test

The split tensile strength [21] of geopolymer concrete, using sea sand as partial replacement of river sand and seawater were determined at the ages 3, 7, 28 days. Figs. 6 and 7 show the split tensile strength of geopolymer concrete from 65 °C and 90 °C curing temperature. Split tensile strength of geopolymer concrete with seawater and sea sand is considerably lesser than the control geopolymer concrete at the ages of 3, 7 and 28 days. As the curing temperature was increased at 65 °C to 90 °C, the strength was also increased for all mixes.

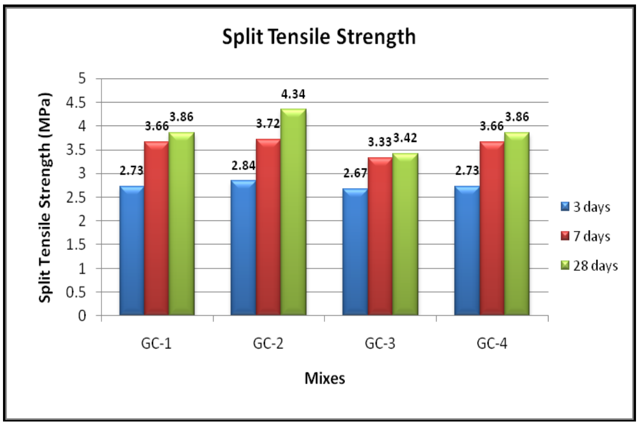


Fig.6 Split tensile strength of geopolymer concrete at 65°C curing temperature

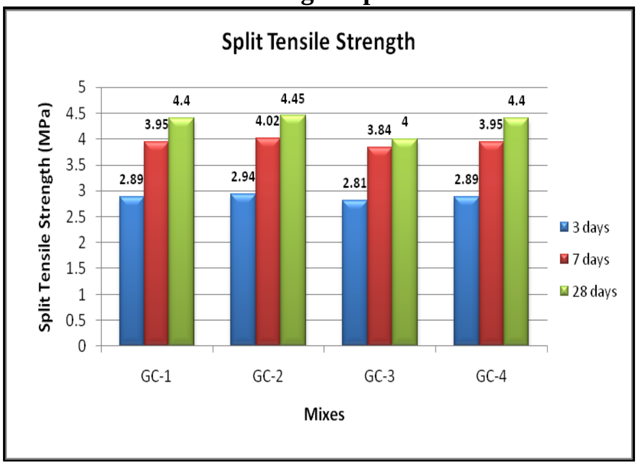


Fig. 7 Split tensile strength of geopolymer concrete at 90°C curing temperature

C. *Flexural Strength Test*

The flexural strength of geopolymer concrete, using sea sand as partial replacement of river sand and seawater were determined at the ages 3, 7, 28 days. Figs.8 and 9 show the flexural strength of geopolymer concrete from 65°C and 90°C curing temperature. Flexural strength of geopolymer concrete with seawater and sea sand is considerably lesser than the concrete geopolymer concrete at the ages of 3, 7 and 28 days. As the curing temperature was increased from 65 °C to 90 °C, the strength was also increased for all mixes.

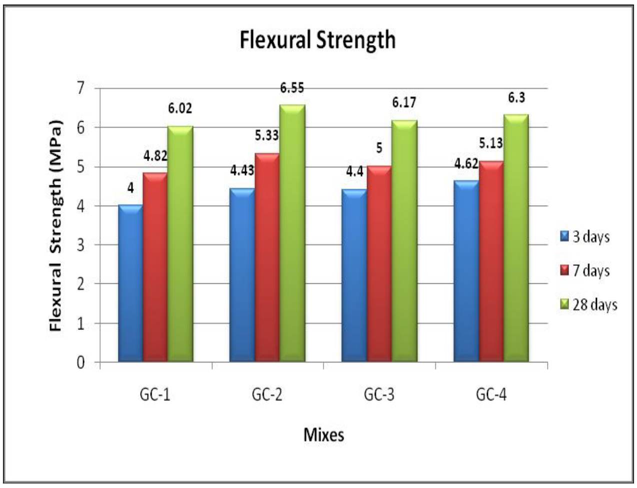


Fig.8 Flexural strength of geopolymer concrete at 65°C curing temperature

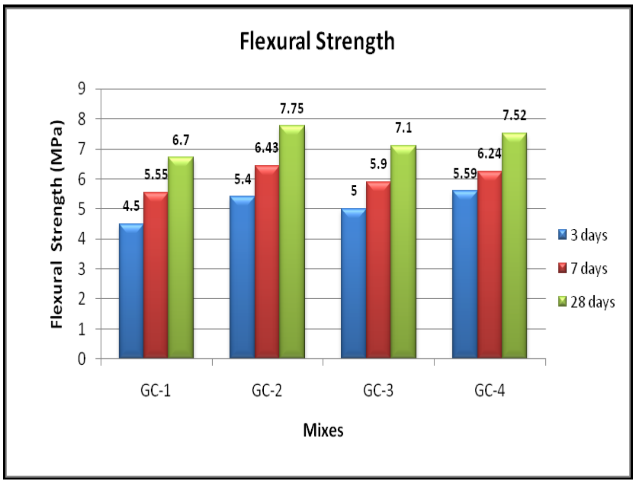


Fig.9 Flexural strength of geopolymer concrete at 90°C curing temperature

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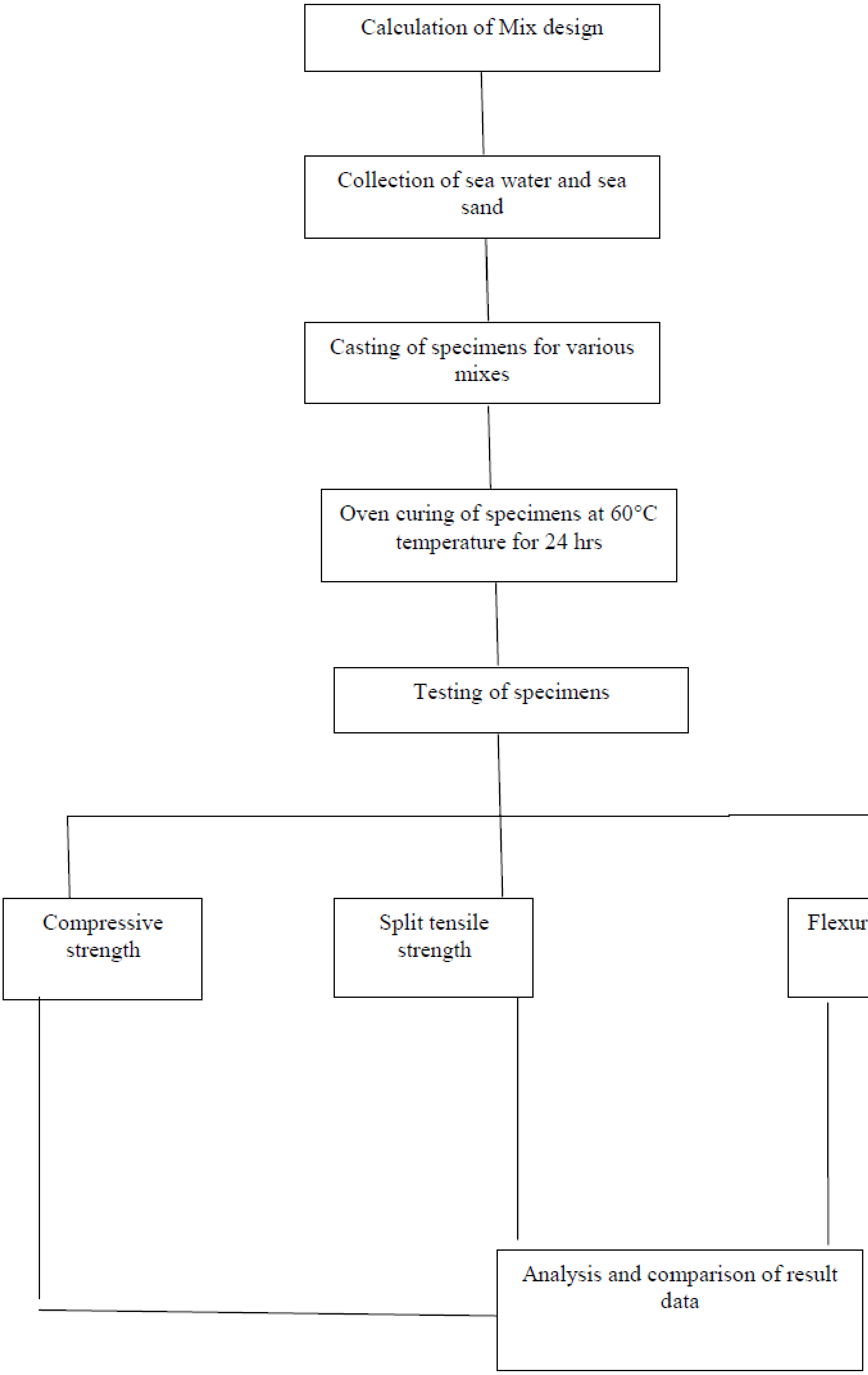

Fig. 1. Research methodology

Table-I: Literature Studies

Sea sand or sea water employed in Geopolymer composites			
Sr. No	Authors	Observations	Ref. No
1.	Shinde.B.H and Kadam K.N [1]	The untreated sea sand affects compressive strength in geopolymer concrete same as cement concrete but treated sea sand gives similar results as river sand concrete.	1
2.	Akram. K et al. [22]	Geopolymeric Materials have a strong potential place of conventional concrete due to unique salt resistance properties.	22
Sea sand or sea water used in Concrete Composites			
3.	Limeira et al. [23]	The use of dredged marine sand in substitution of river sand in concrete is maintained or accessible pores. Sorptivity and water penetration depth.	23
4.	Karthikeyan .M and Nagarajan. V. [24]	Salt content present in sea sand must be eliminated before used in concrete because it contains chloride iron which may corrode steel.	24
5.	Karthikeyan .M and Nagarajan. V [25]	Sea sand in concrete with micro silica results in higher compressive, split and flexural strength than the conventional concrete.	25
6.	Liu. W et al. [26]	Chloride ion which is present in sea sand has some beneficial effect on the carbonation resistance of concrete.	26
7.	Katano. K. et al. [27]	The coefficient of permeability for seawater and unwashed sea sand concrete becomes small compared with that of concrete made using tap water.	27
8.	Ming. C et al. [28]	Compressive strength and elastic modulus of marine sand sea water concrete cured in seawater decrease than that of ordinary concrete cured in fresh water.	28
9.	Huiguang et al. [29]	The mud and clay content of sea sand is lower than that of river sand the fewer clay particles attached to the seasand surface increase bonding between cement and aggregate.	29
10.	Nishida. T et al. [30]	The introduction of blast furnace slag might contribute significantly to the corrosion resistance of steel bar.	30
11.	Mohammed T.U. et al. [31]	No significant difference observed in compressive strength for concrete mixed with sea water and tap water after 20 years of exposure.	31
12.	Sun. W et al. [32]	The chloride ion content of the sea and can improve compressive strength.	32

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Table-V: Mix Proportions for Geopolymer Mortar

Trial Mixes	Fly Ash Kg/m^3	Rice husk ash Kg/m^3	Sea Sand Kg/m^3	River Sand Kg/m^3	NaOH Kg/m^3	Na_2SiO_3 Kg/m^3	Admixture Kg/m^3	Sea Water Content Kg/m^3	Distilled Water Kg/m^3	Remark
G-1	527	0	1586	--	68	169	5.27	71.1	--	Sea Sand And Sea Water was used
G-2	474.3	52.7	--	1586	68	169	5.27	--	71.1	River sand and Distilled Water was used
G-3	421.6	105.4	1586	--	68	169	5.27	--	71.1	Sea Sand And Distilled Water was used
G-4	368.9	158.1	--	1586	68	169	5.27	71.1	--	River sand and Sea Water was used

Table-VI: Mix Proportions for Geopolymer Concrete

Trial Mixes	Fly Ash Kg/m^3	Sea Sand Kg/m^3	River Sand Kg/m^3	Coarse aggregate (20mm and 10mm) Kg/m^3	NaOH Kg/m^3	Na_2SiO_3 Kg/m^3	Admixture Kg/m^3	Distilled Water Kg/m^3	Sea Water Kg/m^3	Remark
GC-1	446.43	656.25	--	1218.75	51.02	127.55	8.93	--	22.32	Sea Sand And Sea Water was used
GC-2	446.43	--	656.2 5	1218.75	51.02	127.55	8.93	22.32	--	River Sand And Distilled Water was used
GC-3	446.43	656.25	--	1218.75	51.02	127.55	8.93	--	22.32	Sea Sand And Distilled Water was used
GC-4	431.03	---	656.2 5	1218.75	51.02	127.55	8.93	22.32	--	River Sand And Sea Water was used
GC-5	431.03	656.25	--	1218.75	55.42	138.55	8.62	--	21.55	Sea Sand And Sea Water was used
GC-6	431.03	--	656.2 5	1218.75	55.42	138.55	8.62	21.55	--	River Sand And Distilled Water was used

GC-7	431.03	656.25	--	1218.75	55.42	138.55	8.62	--	21.55	Sea Sand And Distilled Water was used
GC-8	431.03	---	656.25	1218.75	55.42	138.55	8.62	21.55	--	River Sand And Sea Water was used

VIII. CONCLUSION

The research draws the following findings from experimental outcomes:

1) The replacement of 0%, 10%, and 20% of fly ash with RHA in fly ash-based geopolymer mortar resulted in higher 7 days compressive strength than the 28-day compressive strength of corresponding conventional H1-type cement mortar, i.e. 10 MPa. This verifies the high and early strength gain of geopolymer mortars; hence, geopolymer-based mortar should be used in construction works where the speed of construction is essential.
2) Geopolymer mortar performs satisfactorily when it has saline material as its constituents, i.e. using sea water instead of normal water, sea sand instead of river sand, or both sea sand and sea water instead of river sand and normal water. In all such combinations, the resulting 7-day compressive strength was again higher than the 28-day compressive strength of the corresponding conventional H1-type OPC mortar (10 MPa).
3) It also confirms the feasibility of using locally available sea sand and sea water in geopolymer mortar for coastal area construction, as the compressive strength of all four combinations are in a comparable range and well above the H1 quality mortar.
4) A significant decrease in compressive strength, Flexural strength and Split tensile strength were observed in geopolymer composites fabricated with seawater and sea sand.

REFERENCES

1. B.H. Shinde, Dr. K.N. Kadam, Strength properties of fly ash based geopolymer concrete with sea sand, American journal of engineering research (7), 2016, 129-132.
2. S. Luhar, T.-W. Cheng, D. Nicolaides, I. Luhar, D. Panias, K. Sakkas, Valorisation of glass wastes for the development of geopolymer composites – durability, thermal and microstructural properties: a review, Constr. Build. Mater. 222 (2019) 673–687, https://doi.org/10.1016/j.conbuildmat.2019.06.169.
3. S. Luhar, T.-W. Cheng, D. Nicolaides, I. Luhar, D. Panias, K. Sakkas, Valorisation of glass waste for development of Geopolymer composites – mechanical properties and rheological characteristics: a review, Constr. Build. Mater. 220 (2019) 547–564, https://doi.org/10.1016/j.conbuildmat.2019.06.041.
4. S. Luhar, T.-W. Cheng, I. Luhar, Incorporation of natural waste from agricultural and aquacultural farming as supplementary materials with green concrete: a review, Compos. B Eng. 175 (2019), https://doi.org/ 10.1016/j.compositesb.2019.107076 107076.
5. S. Luhar, P. Chaudhary, I. Luhar, Influence of Steel Crystal Powder on Performance of Recycled Aggregate Concrete 431 (2018) 102003, https://doi.org/10.1088/1757-899x/431/10/102003.
6. S. Luhar, S. Gourav, A review paper on self healing concrete, J. Civ. Eng. Res. 5 (3) (2015) 53–58, https://doi.org/10.5923/j.jce.20150503.01.
7. S.Luhar, I.Luhar, Strength improvement studies of bacterial concrete, Indian Concrete Journal 2017, 91 (10),pp. 12-16.
8. S. Luhar, Performance evaluation of rubberized geopolymer concrete and fly ash based geopolymer mortar. Thesis. 2018.
9. B.V. Rangan, Djwantoro Hardjito, Steenie E Wallah, Dody MJ Sumajouw, "Properties and Applications of Fly Ash-BasedConcrete" Material Forum Volume 30- 2006, pp. 170-175.
10. S. Luhar, I. Luhar, Application of artificial neural network for predicting compressive strength of geopolymer concrete, Indian Concrete Journal, 2019, 98 (2), pp. 38-43.
11. F.U.A. Shaikh, S. Luhar , H. Arel, I. Luhar, Performance evaluation of Ultrahigh performance fibre reinforced concrete – A review, Construction and Building Materials 232 (2020) 117152, https://doi.org/10.1016/j.conbuildmat.2019.117152.
12. S. Luhar, U.V.Dave, Investigations on mechanical properties of fly ash and slag based geopolymer concrete, Indian Concrete Journal, 2016, 90 (2), pp.34-41.
13. Choudhary V., S.Luhar, Fly ash utilization: A review, International Journal of Civil Engineering and Technology, 2017, 8 (4), pp. 301-312.
14. S. Luhar, Fly, ash and Slag based geopolymer concrete: experimental facts. LAP Lambert Academic Publishing; 2016.
15. S.Luhar, I.Luhar, Fly Ash Based Geopolymer Mortar- Strength Performance, International Journal of Recent Technology and Engineering (IJRTE), 8(5), January 2020.
16. S.Luhar, I.Luhar, Rubberized geopolymer concrete: Application of Taguchi method for various factors, International Journal of Recent Technology and Engineering (IJRTE), 8(5), January 2020.
17. T Nishida, N Otsuki, H Ohara, Z M Garba, T Nagata, Some considerations for the applicability of sea water as mixing water in concrete, 3rd international conferenceSustainable construction materials and technologies.
18. IS: 516- 1959, Methods of tests for strength of concrete, Bureau of Indian Standards, New Delhi, 1959.
19. IS:2250 -1981, Code Of Practice for Preparation and Use of Masonry Mortars, Bureau of Indian Standards, New Delhi,1981.
20. S.Luhar, I..Luhar,Fly Ash Based Geopolymer Mortar - Carbonation And Microstructural Performance, International Journal of Recent Technology and Engineering (IJRTE), 8(5), January 2020.
21. IS: 5816-1999, Splitting tensile strength of concrete method of test, Bureau of Indian Standards, New Delhi, 1999.
22. M A Khan, P Padmakaran, S. S. Amritphale S. Das, Potential Application of Sea Sand and Sea Water as Advanced Geopolymeric Material: Novel Initiative of the Millennium.
23. J Limbra, M. Etxeberria, L Agullo, D. Molina, Mechanical and Durability properties of concrete made with dredged marine sand, Construction and building materials, (25), 2011, 4167-4174.
24. M karthikeyan, V Nagarajan, Chloride analysis of sea sand for making concrete, National Academy Science Letters, 2016.
25. M karthikeyan, V Nagarajan, Feasibility study on utilization of marine sand in concrete for sustainable development, Indian Journal of Geo marine sciences,(2),2016, 313-318.
26. W Liu, H Cui, Z Dong, F Xing, H Zhang, T. Y. Lo, carbonation of concrete made with dredged marine sand and its effect on chloride binding, Construction and Building Materials, (120), 2016, 1-9.
27. K Katano, N F Takeda, Y Ishizeki, K Iriya, Properties and Application of Concrete Made with Sea Water and Un-washed Sea Sand, Third International Conference on Sustainable Construction Materials and Technology, Obayashi Corporation, Japan.
28. C Ming, J Z Mao, D Guang, L Ben, Experimental study on mechanical properties of marine sand and seawater concrete, International conference on mechanics and civil engineering, 2014.
29. Y. Hunguang, L. Yan, L.Henglin, G Quan, Durability of Sea sand containing concrete: effects of chloride ion penetration, Mining Science and Technology, 21, 2011, 123-127.
30. T Nishida, N Otsuki, H Ohara, Z M Garba, T Nagata, Some considerations for the applicability of sea water as mixing water in concrete, 3rd international conferenceSustainable construction materials and technologies.
31. T U Mohammed, H Hamada, T Yamaji, Performance of seawater mixed concrete in the tidal environment, Cement and concrete research, (34), 2004, 593-601.
32. W sun, J Liu, Y Dai, J Yan, Study on the influence of chloride ions content on the sea sand concrete performance, American journal of civil engineering, (2), 2016, 50-54.

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