Experimental Study of Mechanical and Durability parameters of Sustainable Concrete

[1]Mrs Ashwini R. Patil, [2]Riya Khalate, [3]Pushpak Zambare, [4]Rohan Rathod, [5]Sohan Lakde

[1]Assistant Professor, [2,3,4,5]UG Students
DY Patil College of Engineering Akurdi, Pune

***Abstract*: Our projects aim to make sustainable concrete. To alleviate the scarcity of drinking water, sea water can be used in the construction for mixing and curing, with sea sand replacing river sand, and GGBS and Fly ash as supplementary cementitious materials, resulting in a sustainable concrete that can be used in societies where fresh water is scarce.**

In this research, the mechanical properties such as Compressive strength, Flexural strength, Split Tensile strength of the specimens were investigated. This study also looked at the specimens' durability properties, such as Sorptivity , and the Rapid Chloride Penetration Test.

From previous literature reviews, the use of sea water is likely to enhance the strength growth of the concrete at early stages due to the high chloride content in sea water. According to most research, seawater concrete has a much higher 7-day compressive strength, a comparable 28-day compressive strength, and a later drop in long-term compressive strength than regular concrete.

In this research, the specimen comprised of Ordinary Portland Cement (OPC 43 grade) with other binding materials like Ground Granulated Blast Furnace Slag (GGBS), Fly Ash, sea sand and river sand which were subjected to wetting drying cycles. The concrete specimen consists of 50% cement, 25% GGBS, 25% Fly Ash as binding material, 50% river sand and 50% sea sand as fine aggregates and gravels as coarse aggregate. The specimen was casted and cured in both tap water and sea water for 7 days, 28 days, 56 days and the results for the tests were noted. Also, these results were compared with convectional concrete cubes.

When cured in tap water, the cubes' compressive strength was 33.71 N/mm2 after 7 days, 34.66 N/mm2 after 28 days, and 47.11N/mm2 after 56 days, whereas when cured in sea water, the cubes' compressive strength was 32.44 N/mm2 after 7 days, 38.665N/mm2 after 28 days, and 41.77 N/mm2 after 56 days. As the curing time went on, the strength of the cubes improved. In addition, the strength of tap water and sea water curing were nearly identical.

The findings of this study show the necessity for more research into the properties of seawater and its use in concrete mixing and curing.

INTRODUCTION

Concrete is one of the most widely used construction materials in the world (Chemistry World 2008). It is estimated that between 21–31 billion tonnes of concrete were consumed worldwide in 2006 [1]. The building sector is expanding rapidly, which raises demand for concrete, which contains cement, coarse aggregate, and fine aggregate.

Concrete demand has risen quickly as a result of rising urbanisation and industrialization. The majority of the materials used in this building are river water and river sand. However, the availability of these resources is limited, and they are not available locally, raising the construction's transportation costs.[2] The cost of concrete can be reduced by replacing some amount of cement with fly ash and GGBS.

River sand is likewise in extremely high demand. Sand is taken from the riverbed via mining. However, due to the widespread extraction of river sand, which has harmed the riverbed, the government has enforced a variety of mining and construction regulations. The mafias have resorted to illegal sand mining as a result of this. As a result, river sand is scarce, which has an impact on construction costs. Sea sand, which is readily available and less expensive, can be used instead of river sand. This would gradually lower construction costs.

The earth's surface is covered by about 71 percent water, with 96.5 percent of the water being in the oceans and only 2.5 percent being freshwater, with less than 0.8 percent of the freshwater being drinkable (Perlman 2016).

Climate Change has been exacerbated by the recent expansion in urbanisation. The rise in global average land and sea temperatures has resulted in rising sea levels, broad reductions in snow and ice cover, changes in atmospheric and ocean circulation, and changes in regional weather patterns, all of which have influenced seasonal rainfall conditions (DEE 2019).

Using seawater as a substitute for freshwater in concrete-based building could help to improve global quality of life while also ensuring that freshwater sources are preserved for future generations.

Thus, our project aims to use natural resources effectively for development of sustainable concrete. Here, we used sea sand and sea water as a replacement for crushed sand and river water respectively.

MATERIALS USED

Tap water or seawater were used to mix mortar specimens. OPC, fly ash and GGBS were used to make them.

OPC (Ordinary Portland Cement), grade 43, conforming to IS 8112-1989 was used.

The materials' physical attributes and chemical compositions of OPC are summarized in table 1 and table 2

Table 1. Physical properties of OPC cement

Physical Properties						
Setting Time	3 days	7 days	28days	3days	7days	28days
Average compression strength (N/mm2)	23	33	43	12	19	-
Fineness in m2/kg min	225					
Soundness						
(a)lee Chatelier method, mm, max	10					
(b)autoclave test method, %, max	0.8			0.8		
Setting time						
(a)initial in min, min	30			Not less than 45		
(b)final in min, max	600			Not less than 375		
Code reference	IS 8112:1989					

Table 2. Chemical properties of OPC cement

Sr No.	Characteristics	requirement
1	Ratio of percentage of alumina to that of iron oxide	0.66
2	Insoluble residue, percent by mass, max	4.0
3	Magnesia, percent by mass, max	6.0
4	Total sulphur content calculated as sulphuric anhydride (SO3), percent by mass, max	3.5
5	Loss on ignition, percent by mass, max	5.0
6	Chloride content, percent by mass, max	0.1
7	Alkali content	0.05

Two types of sand, sea sand and crushed / river sand were used.
Crushed sand of 10mm was used as fine aggregate.
Fly Ash is a byproduct of coal-fired electric generating plants. The main composition of fly ash is Silica dioxide (Sio2), Ferric oxide (Fe203), Aluminum oxide (Al2O3), Calcium oxide (Cao). It is a pozzolans and binding material. Here fly ash is used as partial replacement to cement.[3]

Table 3. Chemical Properties of Fly Ash

Sr no	Characteristic	Siliceous Fly Ash	Calcareous Fly Ash
1	Silicon dioxide (SiO2) plus aluminum oxide (Al2 O3) plus iron oxide (Fe2 O3) in percent by mass, Min	70	50
2	Silicon dioxide (SiO2) in percent by mass, Min	35	25
3	Reactive silica in percent by mass1), Min	20	20
4	Magnesium oxide (MgO) in percent by mass, Max	5	5
5	Total Sulphur as Sulphur trioxide (SO3) in percent by mass, Max	3	3
6	Available alkalis as equivalent sodium oxide (Na2 O) in percent by mass, Max	1.5	1.5
7	Total chlorides in percent by mass, Max	0.05	0.05
8	Loss on ignition in percent by mass, Max	5	5

Table 4. Physical Properties of Fly Ash

Sr No	Characteristic	Requirements
1	Fineness — Specific surface in m2 /kg by Blaine's permeability method, Min	320
2	Particles retained on 45 micron IS sieve (wet sieving) in percent1), Max	34
3	Lime reactivity — Average compressive strength in N/mm2, Min	4.5
4	Compressive strength at 28 days in N/mm2, Min	Not less than 80 percent of the strength of corresponding plain cement mortar cubes
5	Soundness by autoclave test — Expansion of specimen in percent, Max	0.8

GGBS is a off-white cementitious binding material produced by the quenching process that is the process of sudden cooling of ions slag from a blast furnace using water or stream. At the end of the process a glassy, granular product is obtained and then dried and grinded into fine powder.[3]

Experimental Programme

32 cubes were casted of M30 mix were casted for compressive strength test. 4 beams and 4 cylindrical specimen were casted for flexural and split tensile test respectively. Cubes of 150*150*150 mm were casted. They were demolded after 24 hrs. and were cured in tap water and sea water for 7 days ,28 days, and56 days and were tested. Beams of 150*150*450 mm and cylindrical specimen of 300*150mm were casted. They were demolded after 24 hrs. and were cured for 28 days in tap water and sea water.

TESTS

Compressive Strength test

Cubical specimen of 150*150*150 mm cured in tap water and sea water for 7 days ,28 days and 56 days are tested in compression testing machine. The load shall be applied slowly without shock and increased continuously at a rate of approximately 140 kg/sq.cm/min until the resistance of the specimen to the increased load breaks down and no greater load can be sustained. The maximum load applied to the specimen shall then be recorded and any unusual features noted at the time of failure brought out in the report.

Flexural Strength Test

Beams of 150 *150*450 mm size cured in both sea water and tap water were tested at 28 days and 56 days respectively on Flexural Testing Machine. The load shall be applied at a rate of loading of 400 kg/min for the 15.0 cm specimens and at a rate of 180 kg/min for the 10.0 cm specimens**.** Circular rollers having cross section with diameter 38 mm will be used for providing support and loading points to the specimens. The length of the rollers shall be at least 10 mm more than the width of the test specimen. A total of four rollers shall be used, three out of which shall be capable of rotating along their own axes. The distance between the outer rollers (i.e. span) shall be 3d and the distance between the inner rollers shall be d. The inner rollers shall be equally spaced between the outer rollers, such that the entire system is systematics.

Split Tensile Strength Test

Cylindrical specimen of 150 *300mm cured for 28 and 56 days cured in tap as well as sea water are tested on compression testing machine .The load shall be applied at a rate of loading of 400 kg/min for the 15.0 cm specimens and at a rate of 180 kg/min for the 10.0 cm specimens**.** surfaces of the specimens which are to be in contact with the rollers.

Two bearings strips of nominal (1/8 inch i.e. 3.175 mm) thick plywood free of imperfections approximately (25 mm) wide and of length equal to or slightly longer than that of the specimen should be provided for each specimen.

These two bearing strips (plywood strips) are placed between the specimen and both the upper and lower bearing blocks of the strength testing machine. Also they can be placed between the specimen and the supplemental bars or plates.

Now draw diametric lines at each end of the specimen using a suitable device that will make sure that they are in the same axial plane.

One of the bearing strips (plywood strips) will be centered along the centre of the lower bearing block. The specimen will be placed on the bearing strip (plywood strip) and aligned carefully so that the lines marked on the ends of the specimen will be vertical and cantered over the plywood strip. The second plywood strip (bearing strip) will be placed lengthwise on the cylinder, cantered on the lines marked on the ends of the cylinder. The load will be applied continuously and without shock, at a constant rate within, the range of 689 to 1380 kPa/min splitting tensile stress until failure of the specimen.

Sorptivity Test

According to ASTM C1585 [4], a sorptivity test was performed to determine the rate of water absorption of concrete. The test was done on concrete samples that had been cured for 28 days and 90 days. Covington slab saw was used to trim samples of 200mm x100mm into dimensions of 100 mm x 50 mm. After that, the samples were baked for 7 days at 50 degrees Celsius. The samples' top surfaces were sealed, whereas the bottom faces were in touch for absorption with water, for 8 days. The mass variations of the samples were measured. After that, the initial and secondary sorption's were computed.

Rapid chloride permeability testing

The permeability of each mix's concrete was also tested using a rapid chloride ion penetration test. This investigation followed the ASTM C1202 [5] approved test technique. Concrete samples in the shape of a cylinder with a diameter of 100 mm x 50 mm were left to cure for 28 days.Prior to the examination the samples were attached to two electrodes after usual conditioning.One cell was filled with 3.0% NaCl solution, while the other cell was filled with 0.3 N NaOH solution. The electric current flowing through the samples was measured after 6 hours and charge corresponding to it was determined.

RESULTS

Compressive Strength Test

	Mix Type	TW 7 Days (N/mm2)	TW 28 Days (N/mm2)	TW 56 Days (N/mm2)
Compressive Strength Tap Water Curing	M30	33.71	34.66	47.11
Compressive Strength Sea Water Curing	M30	39.11	37.55	41.33

Flexural Strength Test

	Mix Type	28 Days Tap water Curing (N/mm2)	56 Days Tap water Curing (N/mm2)
Flexural Strength Tap Water Curing	M30	-	7.12
Flexural Strength Sea Water Curing	M30	-	7.476

Split Tensile Strength Test

	Mix Type	28 Days tap water Curing (N/mm2)	56 Days tap water Curing (N/mm2)
Strength Sea Water Curing	M30	-	3.25
Split Tensile Strength Tap Water Curing	M30	-	2.89

Conclusion

The compression strength test of the specimen were and the split tensile strength were 3.25 N/mm2 and 2.89 N/mm2 cured in Tap water and sea water respectively. The flexural strength were 7.12 N/mm2 when cured in tap water and 7.476 when cured in sea water. It is observed that there the results obtained from sea water and tap cured curing does not have much difference.

REFERENCES

[1] Tanaz Dhondy, Alex Remennikov & M. Neaz Shiekh, Benefits of using sea sand and seawater in concrete: a comprehensive review

[2] Matthew Zhi Yeon Ting, Kwong Soon Wong , Muhammad Ekhlasur Rahman, Meheron Selowara Joo ,Mechanical and durability performance of marine sand and seawater concrete incorporating silicomanganese slag as coarse aggregate

[3] Shanmuganathan.N , Akbar Basha.S , Sheikibrahim.K , Mohammed fahad.A.S , Ground Granulated Blast Furnace Slag (Ggbs or Ggbfs) and Fly Ash (Fa) in Concrete – A Study Report

[4] ASTM C150, Standard specification of Portland cement. 2012, American Society for Testing and Materials: West Conshohocken, PA.

[5] ASTM C33, Standard specification for concrete aggregates. 2012, American Society for Testing and Materials: West Conshohocken, PA.

[6] ASTM C39, Standard test method for compressive strength of cylinderical concrete specimens. 2012, American Society for Testing and Materials: West Conshohocken, PA.

[7] ASTM C496, Standard test method for splitting tensile strength of cylindrical concrete specimens. West American Society for Testing and Materials 2012 Conshohocken, PA

[8] ASTM C642, Standard test method for density, absorption and voids in hardened concrete. 2012, American Society for Testing and Materials: West Conshohocken, PA.

[9] ASTM C1585, Standard test method for measurement of rate of absorption of water by hydraulic-cement concrete. 2012, American Society for Testing and Materials: West Conshohocken, PA.

[10] ASTM C1202, Standard test method for electrical indication of concrete's ability to resist chloride ion penetration. 2012, American Society for Testing and Materials: West Conshohocken, PA.

[11] ASTM C1012, Standard test method for length change of hydraulic-cement mortars exposed to a sulfate solution. 2012, American Society for Testing and Materials: West Conshohocken, PA.