Experimental Investigations on Partial Replacement of Fine Aggregate by Onshore Marine Sand using Corossion Inhibitor

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INTRODUCTION

1.1. GENERAL

Corrosion is the main problem which will cause various harmful effects in construction industry. Now a days the coastal region was generally facing various problems of corrosion. Various artificial admixtures are used for preventing corrosion based problems but economical charges for these materials are very high and also cause toxic effects over the structures. The usage of natural admixtures will be utilized for providing nontoxic and good economical provisions in construction industry

There is increasing concern about the toxicity of corrosion inhibitors in industry. The toxic effects not only affects living organisms but also poison the earth. The following chapter provides a brief introduction to corrosion. It also describes the corrosion inhibitors employed and the toxicity of such chemicals.

1.2. CORROSION

Corrosion can be defined as the disintegration of a material or its properties by electrochemical reaction when interacting with its surrounding environment. Thus the corrosion is the reaction of an engineering material with its environment leading to a consequent deterioration in properties of the material.

For corrosion to occur, three essential elements must be present:

a. Electrolyte
b. Anode
c. Cathode

An electrolyte is a solution can conduct electric current. An electrolytic liquid refers to any liquid that contains ions. Electrodes can be of different metals or the same metal with different sizes or areas.

1.3. inhibitors

Inhibitors function by adsorption of ions or molecules onto metal surface. They reduce the corrosion rate by

- Increasing or decreasing anodic or cathodic reaction
- Decreasing the diffusion rate for reactants to the surface of metal
- Decreasing the electrical resistance of the metal surface

Corrosion inhibitors may be inorganic compounds such as calcium nitrite or organic compounds containing electronegative heteroatoms. The three most common generic types of corrosion inhibiting admixture are calcium nitrite. Electronegative hetero atom and those compounds blended with inorganic inhibitor. There are many investigations on use of inhibitors for corrosion of steel.

Most of the commercial inhibitors are either toxic or show adverse effect on concrete properties. Further the environmental legislations have restricted the use of many inhibitors. To overcome this, development of environmentally and eco-friendly inhibitors are essential to reduce corrosion rate by neutralizes alkali silica reactions, fills pores of concrete to inhibit penetration of moisture, deters intrusion of moisture, chlorides and oxygen and increase the density and hardness of concrete, which improves bonding of patching materials, hence increase physical, mechanical properties and thereby increase the durability.

1.4. friendly inhibitors

The eco-friendly green inhibitors generally consist of nontoxic properties and effective corrosion inhibitors range from rare earth elements to organic compounds.

1.5. EFFECTS OF CORROSION

1.5.1. FORMATION OF WHITE & BROWN PATCHES

CO2 reacts with Ca(OH)2 in the cement paste to form CaCO3. The free movement of water carries the unstable CaCO3 towards the surface and forms white patches. It indicates the occurrence of carbonation.

When the reinforcement starts corroding, a layer of ferric oxide is formed. This brown product resulting from corrosion may permeate along with moisture to the concrete surface without cracking of the concrete.

1.5.2. OCCURANCE OF CRACKS

The increase in volume exerts considerable bursting pressure on the surrounding concrete resulting in cracking. The hair line crack in the concrete surface lying directly above the reinforcement and running parallel to it is the positive visible indication that reinforcement is corroding. These cracks indicate that the expanding rust had grown enough to split the concrete.

1.5.3. FORMATION OF MULTIPLE CRACKS

• As corrosion progresses, formation of multiple layers of rust on the reinforcement which in turn exert considerable pressure of the surrounding concrete resulting in widening of hair cracks. There will be a hollow sound when the concrete is tapped at the surface with a light hammer.

1.6. about the project

For decades, attempts are being made to inhibit the corrosion in concrete by using naturally or artificially produced admixtures or inhibitors that reduce the corrosion in concrete and hence RCC. The buildings in and around the sea side areas are mainly subjected to corrosion because they are exposed to saline environment. It is because of this salinity, the plastering gets removed from the buildings and air percolates in to the concrete through tiny air gaps and thus the steel reinforcement gets corroded finally.

In this experimental project, I am attempting to reduce the corrosion in concrete and cement mortar by replacing fine aggregate with various percentages of green admixture and on shore marine sand (0.5%, 1%, 1.5%, 2%, 2.5%, 3% and 5%, 10%, 15%, 20%, 25% respectively). The compressive strength test, flexural strength test, water absorption test, ultra sonic pulse velocity test and pull out test are planned to conduct. The strength when on shore marine sand is added as replacement to fine aggregate is going to examine and also changes that may going to cause with the addition of Tamarindus seed will also be estimated

1.7. objective of the project

Following are the main objectives of the present study;
To use onshore marine sand and tamarindus seed extract

- For plastering work.
- In concrete, for RCC work.
- For enhancing the strength and durability of plaster and hence RCC.
- Reducing the cost of construction
- Reduction in corrosion in concrete

CHAPTER 2
LITERATURE REVIEW

This chapter presents the work done by various researchers, on the use of onshore marine sand and tamarindus seed extract in concrete and in mortar.

Ahmad S, Al-Kutti WA, Baghabra Al-Amoudi OS, Maslehuddin M (2008) "Correlations between depth of water penetration, chloride permeability, and coefficient of chloride diffusion in plain, silica fume, and fly ash cement concretes" An experimental study was conducted to evaluate correlations between the depth of water penetration, chloride permeability, and coefficient of chloride diffusion in plain, silica fume, and fly ash cement concretes. A total of 27 concrete mixtures were prepared by varying the water to cementitious materials ratio and cementitious materials content and using Type I, fly ash (20 %), and silica fume (7.5 %) cements. The test results were statistically analyzed to develop correlations between the depth of water penetration, chloride permeability, and coefficient of chloride diffusion. A good correlation was noted between the depth of water penetration and chloride diffusion, and chloride permeability and coefficient of chloride diffusion ($R2>0.80$).

Shamsad Ahmad (2009), "Reinforcement corrosion in concrete structures, its monitoring and service life prediction - A review." Reinforcement corrosion has been widely reported in the literature over the last two to three decades. It is one of the major durability problems, mainly when the rebar in the concrete is exposed to the chlorides either contributed from the concrete ingredients or penetrated from the surrounding chloride-bearing environment. Carbonation of concrete or penetration of acidic gases into the concrete, are the other causes of reinforcement corrosion. Besides these there are few more factors, some related to the concrete quality, such as w/c ratio, cement content, impurities in the concrete ingredients, presence of surface cracks, etc. and others related to the external environment, such as moisture, oxygen, humidity, temperature, bacterial attack, stray currents, etc., which affect reinforcement corrosion. The assessment of the causes and extent of corrosion is carried out using various electrochemical techniques. Prediction of the remaining service life of a corroding RC structure is done with the help of empirical models and experimental methods. In this paper a review is presented on the mechanism of reinforcement corrosion, techniques utilized to monitor reinforcement corrosion and methodologies that are utilized for the prediction of remaining service life of structures.

Shamsad Ahmad and B. Bhattacharjee, (2009), "A simple arrangement and procedure for in-situ measurement of corrosion rate of rebar embedded in concrete."In this paper, shear strength and bond strength of pumice concrete were investigated, as well as the application of saturated fine pumice aggregates as an internal curing media for both high performance concrete and ready-mixed full scale thin concrete slabs with a low water-cementitious materials ratio. The development of a vacuum saturation procedure for efficiently saturating pumice aggregates to a wet moisture state has been discussed. The research presented demonstrates the potential to commercially produce high performance lightweight concrete containing naturally occurring pumice aggregates.

JOANN BROWNING, DAVID DARWIN, DIANE REYNOLDS, AND BENJAMIN PENDERGRASS (2011)"Lightweight Aggregate as Internal Curing Agent to Limit Concrete Shrinkage." Pre-wetted vacuum-saturated lightweight aggregate (PVSLWA) is used as an internal curing agent at volume replacement levels ranging from 8.9 to 13.8% for curing periods of 7 and 14 days. PVSLWA results in a small reduction in concrete density, no appreciable effect on concrete compressive strength, and a substantial decrease in concrete shrinkage. Increasing the curing period from 7 to 14 days reduces concrete shrinkage.

BARRETT T. J, DE LA VARGA I., SCHLITTER J, WEISS W. J.(2011), "Reducing the Risk of Cracking in High Volume Fly Ash Concrete by Using Internal Curing." In High Volume Fly Ash (HVFA) Concrete, fine lightweight aggregate (rotary kiln expanded shale) is used as an internal curing agent and high-range water-reducing admixture added at variable dosage by mass of cement.HVFA mixtures with internal curing results in sufficient early-age strength compared to a typical concrete. Autogenous shrinkage and residual tensile stresses are reduced in HVFA mixtures with internal curing.
M. GEETHA AND DR. R. MALATHY(2011), "Comparative study of strength and durability properties of polymeric materials as self-curing agents." In this paper, strength and durability properties are compared in different grades of concrete when added with polymeric materials without any external curing for the concrete. The concrete used were M20, M30, and M40. Of the above tests conducted, the strength as well as the durability property holds good for the cubes with palak green with one day curing and without external curing. It concludes that the cost of internal curing proves to be cheaper when compared with that of external curing.
IGOR DE LA VARGA,JAVIER CASTRO, DALE BENTZ, JASON WEISS, (2012), "Application of inhibitors for Mixtures Containing High Volumes of Fly Ash." In this work, a relatively large percentage of cement (40%, 60%, or 80% by volume) is replaced with Class C fly ash. Internal curing (IC) with prewetted lightweight aggregate was used to reduce shrinkage and increase hydration. HVFA mixtures with w/cm of 0.30 have higher strength at later ages (28 days, 91 days, and 365 days) compared to the reference mortar. A lower modulus of elasticity is obtained when either fly ash, IC, or a combination of both are included in the mixture. IC addition reduces the elastic modulus by an average of 7% and 11% in 40% and 60% fly ash mortars, respectively.
DALE P. BENTZ(2012) "Corrosion mitigation of chloride-81contaminated reinforced concrete structures: A state-of-the-art review." Corrosion is a worldwide problem which costs nations billions of pounds. Although corrosion is not a new problem, awareness of it associated with civil engineering structures, particularly reinforced/pre-stressed concrete highway bridges, multi-storey car-parks and buildings etc. it is relatively new. Corrosion is insidious in nature. Steel corrosion in concrete is only apparent when it is quite advanced. It manifests itself progressively in the form of 'rust' stains, cracking, delamination and finally spalling with exposed and corroding steel reinforcement. Proper application of available science and technology can save a large amount of waste due to corrosion. Over the last two decades a number of corrosion mitigation techniques have been developed. Some are more successful than others. Cathodic protection is the only proven technique to stop corrosion of steel in chloride contaminated concrete
M. V. JAGANNADHA KUMAR, M.SRIKANTH, DR. K. JAGANNADHA RAO (2012), "Protection Systems for Reinforced Concretewith Corrosion Inhibitors." This paper examines the use of corrosion inhibitors in order to protect the reinforcement of concrete. For this purpose mortar specimens were constructed with or without corrosion inhibitors and were partially immersed in sodium chloride. Corrosion inhibitors were used as admixture into concrete and were sprayed on the external surface of mortar specimens. In all mortar specimens, electric junction between reinforcements was achieved. The methods that were used for the evaluation of the reinforcement corrosion in concrete, included half-cell potential measurements, polarization curves of reinforced rebars and mass loss of the reinforcement. Finally, the durability of concrete after the use of corrosion inhibitors was also examined.
Abdulrahman A. S.1,2*, Mohammad Ismail1 and Mohammad Sakhawat Hussain, (2013-IJERT), "Corrosion inhibitors for steel reinforcement in concrete: A review. "Inhibitors are added to concrete to improve its quality and integrity. In recent years the use of these inhibitors in producing high performance concrete has increased significantly as a result of aggressive environment. This report is based on the corrosion inhibitors used in concrete and also on the published literatures. Most authors agreed that reinforcement corrosion is the most important causes of premature failure of reinforced concrete structure worldwide and generate a great research concern due to its effects on global economy. The report presents information related to basic mechanism of corrosion protection methods to extend the service life of reinforced concrete structures which include inhibitors, sealers and barriers. Environmental sustainability issues concerning the present inhibitors being used were examined, viability and versatility of green inhibitors to concrete was also x-rayed.

CHAPTER 3
METHODOLOGY

3.1 GENERAL

This chapter briefly explains the methodology adopted in this experimental work. Materials required for the proceeding works were collected from the nearby sources; the various material required are seeds of tamarindus, albezia, mild steel rod, cement, fine aggregate and coarse aggregate. The various materials collected are prepared for the testing.
The seeds of tamarindus and albezia were dried in room temperature for one week and they are stored in air tight container for specified time period. And then then the seeds were powdered into fine particles for the initial testing of the work.
Materials that are used for making concrete were clearly stored in containers without with the air. The properties of the materials were obtained through the proper studies. The preliminary tests were conducted for the following materials.

- Seeds of Tamarindus
- Cement
- Fine aggregates
- Coarse aggregates

It should be hard, strong, dense, durable, clean, and free from clay or loamy admixtures or quarry refuse or vegetable matter. The pieces of aggregates should be cubical, or rounded shaped and should have granular or crystalline or smooth (but not glossy) non-powdery surfaces. Aggregates should be properly screened and if necessary washed clean before use. Coarse aggregates containing flat, elongated or flaky pieces or mica should be rejected. The grading of coarse aggregates should be as per specifications of IS 383-1970.

In this project, maximum normal size of coarse aggregate is 20mm for controlled concrete.

3.2.2. WATER

The water should be fit for mixing. The water should not have high concentrations of sodium and potassium and there is a danger of alkali-aggregate reaction. Natural waters that are slightly acidic are harmless, but water containing humic or other organic acids may adversely affect the hardening of concrete. Such water as well as highly alkaline water should be tested. The water should conform to IS 456-2000 standards. Generally, water satisfactory for mixing is also suitable for curing purposes. However, it is essential that curing water should be free from substances that attack hardened concrete like free CO2 etc.

3.2.3. ONSHORE MARINE SAND

The onshore marine sand used for the project was collected from an area around Kovalam sea shore. The sample of onshore marine sand used is as mentioned in figure 3.2

Fig 3.2.5 Sample of onshore marine sand

3.2.4. TAMARINDUS SEED EXTRACT

Tamarind seed is a by-product of the commercial utilisation of the fruit, however it has several uses. The seed consists of decorticated kernels contained 46-48% of a gel forming substance. Tamarind seed has shown a relatively high level invitro protein digestibility. The proteins have a favourable amino acid composition and could supplement cereals and legumes poor in methionine and cysteine. They also contain small amounts of anti nutritional factors (tannins, phytic acid, hydrogen cyanide, trypsin inhibitor activity and phytohaemaglutinating activity).

The pectin of tamarind generally consists of moisture 7.7-9.9%, ash 2.3-3.0%, Calcium pectate 70-80.4%, Methoxyl 7.9-9.9%, Uronic acid 43-56.4%.

The seed comprises the seed coat or testa (20-30%) and the kernel or endosperm (70-75%). Tamarind seed is the raw material used in the manufacture of tamarind seed kernel powder, polysaccharide and adhesive. Whole tamarind seed and kernels are rich in protein (13-20%).

3.2.6.1 PREPARATION OF EXTRACT POWDER

The freshly collected seeds were washed perfectly in ordinary tap water. Then the material was dried in room temperature for one week time period. After drying of the seeds they have been grinded into fine powders and the powder was sieved through 600 micron sieve

Fig 3.2.6 Tamarind seed powder

Table 3.2.6: Properties of Tamarind seed powder

TMS powder	
Protein	13-20%
Calcium pectate	70-80.4%
Uronic Acid	43-56.4%
methoxyl	7%
Starch	109.1g/kg

3.3 PRELIMINARY TEST FOR CEMENT

3.3.1. TEST FOR FINENESS OF CEMENT

A 100g of cement was taken and sieved in a standard IS 90μcontinuously for 15 minutes using sieve shaker. The weight of residue left on the sieve is noted.

Table 3.3.1: Fineness of cement

S.No	Description	Trial No.1	Trial No.2	Trial No.3
1	Wt of Cement taken	100g	100g	100g
2	Wt of Cement Retained	2g	2g	2g
3	Percentage of residue left on 90μ sieve	2	2	2

Fineness of cement = (weight retained/weight taken) x 100

Fineness of cement = 2%

3.3.2. TEST FOR NORMAL CONSISTENCY OF CEMENT

A 400g of cement is taken and a paste is prepared with weighed qty of water (say 26%) is prepared. The paste is filled in the given mould and shaking well to exit air. A standard plunger of 10mm diameter and 50mm long is attached to the Vicat's apparatus and bought down to touch the surface of the paste in the test block and is quickly released to sink in to the paste by its own weight. The depth of penetration of the plunger is noted.

The second trial is conducted by adding 28% of water and the depth of penetration is noted. Similarly, number of trials was conducted, till the plunger penetrate to a depth of 33mm to 35mm.

Table 3.3.2: Consistency Test of Cement

Trial No.	Weight of cement(g)	% of Water	Amount of water(ml)	Reading of pointer from bottom
1	400	26	104	37
2	400	28	112	34
3	400	30	120	15
4	400	31	124	11
5	400	31.25	125	6

Consistency of cement = 31.25%

3.3.3. TEST FOR INITIAL SETTING TIME OF CEMENT

A cement paste is prepared with 0.85 times of water to standard consistency; the time at which the water is added is noted. The Vicat's Mould is filled with the cement paste and the surface is smoothened. The needle is gently lowered of the surface of the paste and is quickly released allowing it to sink into the paste by its own weight. The procedure is repeated until the 1mm square needle is failed to pierce the block for about 5-7mm measured from bottom and the time is noted using stop watch. The difference between the timing will give the initial setting time.

Table 3.3.3: Initial Setting Time of Cement

S.No	Time in minutes	Pointer reading from bottom
1	0	0
2	3	0
3	6	1
4	9	3
5	12	3
6	15	4
7	18	4
8	21	4
9	24	4
10	27	4
11	30	4
12	33	5.5

Initial setting time of cement = 33 minutes.

3.3.4. TEST FOR FINAL SETTING TIME OF CEMENT

The procedure is similar to initial setting time. In this procedure needle with annular collar is inserted in the Vicat's apparatus. Time for penetration is noted every 30minutes. The procedure is repeated until the needle fails to make an impression on the test block.

Table 3.3.4: Final Setting Time Test of Cement

S.No	Time in minutes	Pointer reading from bottom
1	60	7
2	120	15
3	180	25
4	240	33
5	300	34.5
6	360	34.5

Final setting time of cement = 360 minutes.

3.3.5. TEST FOR SPECIFIC GRAVITY OF CEMENT

The empty weight of specific gravity bottle is noted as W1 g. The bottle filled with distilled water and weight taken as W2 g. The specific gravity bottle is filled with kerosene and weight noted as W3 g. Some of the kerosene is taken out and filled with cement and the weight is measured as W4 g. Weight of cement is taken as W5 g.

Table 3.3.5: Specific Gravity of Cement

Specific gravity of kerosene, g = (W3-W1)/(W2-W1)
Specific gravity of cement = [W5/(W5+(W3-W4))] x g
Specific gravity of kerosene = 0.8
Specific gravity of cement= 3.15

3.4 PRELIMINARY TEST FOR FINE AGGREGATE

3.4.1. TEST FOR SIEVE ANALYSIS OF FINE AGGREGATE

The sample is brought to an air-dry condition before weighing and sieving. This may be achieved either by drying at room temperature or heating at a temperature of 10000C to 11000C. The air-dry sample 3 kg taken and sieved successively on the appropriate sieves starting with the largest size sieve as stated in the table. Sieving is carried out on a machine not less than 10 minutes required for each test.
Table 3.4.1: Sieve Analysis Test of Fine Aggregate
Fineness Modulus of sand = 3.18
Sand conforming to zone III.

3.4.2. TEST FOR SPECIFIC GRAVITY OF F.A

The pycnometer is dried thoroughly and its weight is taken as W1. Fill two third part of pycnometer with sand and is weighed as W2. The pycnometer is filled with water up to the top without removing the sand. Then it is shaken well and stirred thoroughly with the glass rod to remove the entrapped air. After the air has been removed, the pycnometer is completely filled with water up to the mark. Then outside of the pycnometer is dried with a clean cloth and is weighed as W3. The pycnometer is cleaned thoroughly. The pycnometer is completely filled with water up to top. Then outside of the pycnometer is dried with a clean cloth and is weighed as W4.

Table 3.4.2: Specific Gravity Test for Fine Aggregate

S. No.	Observations	Trial No 1	Trial No 2	Trail No 3
1	Wt. of empty container (W1g)	644	644	644
2	Wt. of container sample (W2 g)	1201	1097	1109
3	Wt. of container+sample+water (W3 g)	1876	1810	1820
4	Wt. of container water (W4g)	1531	1531	1531
5	Specific Gravity	2.627	2.603	2.642

Specific Gravity of Fine Aggregate = (W2-W1)/[(W2-W1)-(W3-W4)]
Specific Gravity of Fine Aggregate =2.624

3.4.3. TEST FOR MOISTURE CONTENT OF F.A

Weight of empty china dish is taken as W1. Take some quantity of sand in china clay dish, and its weight is taken as W2. Place it in oven for 24 hours. After 24 hours, the sample is again weighed and its weight is taken as W3.

Table 3.4.3: Moisture Content of Fine Aggregate

S. No.	Observations	Trial No 1	Trial No 2	Trail No 3
1	Wt of empty container (W1g)	790	842	1026
2	Wt of container sample (W2 g)	2790	2842	3026
3	Wt of container+ dry sample (W3 g)	2746	2791	2978
4	% of moisture content of fine aggregate	2.2	2.6	2.4

% of Moisture Content of Fine Aggregate = [(W2-W3)/(W3-W1)]x100
% of moisture content of fine aggregate =2.4%

3.4.4. TEST FOR WATER ABSORPTION OF F.A

Take 1000 g of fine aggregate (W1g). The sample is filled with water and kept for 24 hours. After 24 hours immersion, the sample is taken out and dried in air for getting the saturated surface dry condition (SSD).Then, it is weighed (W2g).

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Observations
Wt of sample taken (W1) = 1000g
Wt of sample in SSD state (W2) = 1008g
Water absorption = {(W1-W2)/W1)} x 100
Water absorption=0.8%

3.5 PRELIMINARY TEST FOR COARSE AGGREGATE

3.5.1. teST FOR SIEVE ANALYSIS OF COARSE AGGREGATE

The sample is brought to an air-dry condition before weighing and sieving this may be achieved either by drying at room temperature or heating at a temperature of 10000C to 11000C. The air-dry sample 4 kg taken and sieved successively on the appropriate sieves starting with the largest size sieve as stated in the table. Sieving is carried out on a machine not less than 10 minutes required for each test.

Table 3.5.1 Sieve Analysis Test for Coarse Aggregate

S.No	IS Sieve (mm)	Weight retained (g)	% of wt retained	Cumulative % of wt retained	Cumulative % of passing
1	40	0	0	0	100
2	20	2065	51.62	51.62	48.48
3	12.5	1790	44.75	96.37	3.63
4	10	103	2.57	98.94	1.01
5	4.75	42	1.05	100	0

Fineness Modulus of coarse aggregate = 3.46.

3.5.2. TEST FOR SPECIFIC GRAVITY OF C.A

The container is dried thoroughly and taken its weight as W1. Two-third part of container is filled with coarse aggregate and weighed as W2. The container is filled with water up to the top. Then, it is shaken well and stirred thoroughly with the glass rod to remove the entrapped air. After the air has been removed, the container is completely filled with water up to the mark. Then, outside of the container is dried with a clean cloth and weighed as W3. The container is cleaned thoroughly and completely filled with water up to top. Then, outside of the container is dried with a clean cloth and weighed as W4.
Specific Gravity of Coarse Aggregate = (W2-W1)/[(W2-W1)(W3-W4)
Table 3.5.2: Specific Gravity Test of Coarse Aggregate
Specific Gravity of Coarse Aggregate =2.695

3.5.3. TEST FOR MOISTURE CONTENT OF C.A

Take some quantity of coarse aggregate in china clay dish, weight taken as W1 and place it in oven for 24 hours. After 24 hours taken the sample and weighed as W2.
Observations
Weight of sample taken (W1) =3000g
Weight of sample after dried process (W2) = 2993g
% of free moisture content = {(W1-W2)/W1)} x 100
% of free moisture content of Coarse Aggregate =0.23%

3.5.4. TEST FOR WATER ABSORPTION OF C.A

Take 1000 g of C.A (W1g). The sample is filled with water and kept for 24 hours. After 24 hours immersion, the sample is taken out and dried in air for getting the saturated surface dry condition (SSD). Then, it is weighed (W2g).
Observations
Wt of sample taken (W1) = 3000g
Wt of sample in SSD state (W2) = 3005 g
Wt of oven-dried sample (W3) = 2993 g
Water absorption of coarse aggregate = {(W2-W3/W3)} x100
Water absorption of coarse aggregate = 0.4%

3.6 PRELIMINARY TEST FOR ONSHORE MARINE SAND

3.6.1. TEST FOR SIEVE ANALYSIS OF LWFA

The sample is brought to an air-dry condition before weighing and sieving. This may be achieved either by drying at room temperature or heating at a temperature of 10000C to 11000C. The air-dry sample 4 kg taken and sieved successively on the appropriate sieves starting with the largest size sieve as stated in the table. Sieving is carried out on a machine not less than 10 minutes required for each test
Table 3.6.1: Sieve Analysis Test for onshore marine sand
Fineness Modulus of lightweight aggregate = 3.46.

3.6.2. TEST FOR SPECIFIC GRAVITY OF OSMS

The pycnometer is dried thoroughly and its weight is taken as W1. Fill two third part of pycnometer with OSMS and is weighed as W2. The pycnometer is filled with water up to the top without removing the LWA. Then it is shaken well and stirred thoroughly with the glass rod to remove the entrapped air. After the air has been removed, the pycnometer is completely filled with water up to the mark. Then outside of the pycnometer is dried with a clean cloth and is weighed as W3. The pycnometer is cleaned thoroughly. The pycnometer is completely filled with water up to top. Then outside of the pycnometer is dried with a clean cloth and is weighed as W4.
Specific Gravity of Onshore marine sand = (W2-W1)/[(W2-W1)(W3-W4)]

Table 3.6.2: Specific Gravity Test of Onshore Marine Sand

S. No	Observations	Trial No 1	Trail No 2	Trail No 3
1	Wt of empty container (W1 g)	685	685	685
2	Wt of container + sample (W2 g)	1475	1480	1460
3	Wt of container + sample + water (W3 g)	2009	2018	2005
4	Wt of container + water (W4 g)	1553	1553	1553
5	Specific Gravity	2.36	2.41	2.40

Specific Gravity of Onshore marine sand =2.39

3.7 CONCRETE MIX DESIGN

Concrete mix design is a process of selecting the suitable ingredients of concrete and determining their most optimum proportions which would produce, as economically as possible, concrete that satisfies the job requirements, i.e. the concrete having a certain minimum compressive strength, the desired workability and durability.

3.7.1 AMERICAN CONCRETE INSTITUTE METHOD OF MIX DESIGN

For M20 grade concrete
Input Data
Characteristic strength of concrete - 20 N/mm2
Maximum size of coarse aggregate - 20 mm
Degree of quality control - Good
Type of exposure - Mild
Specific gravity of cement - 3.15
Specific gravity of coarse aggregate - 2.89
Specific gravity of fine aggregate - 2.63
Slump - 50 mm
Dry rodded bulk density of coarse aggregate - 1437.3 kg/m3
Fineness modulus of fine aggregate - 2.66

Step 1:- Calculation of Average design strength
= fck + t × s
[As per IS 10262 – 1982, cl- 2.2, page 56]
From table 2, for 1 in 20, t= 1.65
From table 1, for good quality control and M20 concrete s = 4.5 N/mm2
Thus = 20+1.65x4.5 = 27.4 N/mm2

Step 2:- Water Cement Ratio
The w/c for design strength of 27.4 N/mm2 is 0.5
Referring to table 4, w/c corresponding to I a is 0.58
The least w/c among the two values is 0.5

Step 3:- Determination of Water content
For non- air entrained concrete containing 20 mm aggregate, water content is 185 kg/m3

Step 4:- Determination of Cement content
w/c =0.5
water = 185 kg/m3
Cement = 185/0.5 = 370 kg/m3

Step 5:- Weight of coarse aggregate
From table 2, for 20mm coarse aggregate and fine aggregate of fineness modulus 2.66, the bulk volume of rodded coarse aggregate per unit volume of concrete is 0.634
Density of Coarse aggregate = 1437.3 kg/m3
Weight of coarse aggregate = 1437.3 x 0.634 = 911.24 kg/m3

Step 6:-Density of fresh concrete
For 20 mm aggregate and for non-air entrained concrete, the first estimate of density of fresh concrete = 2355 kg/m3

Step 7:- Weight of ingredients of concrete
Weight of water = 185 kg/m3
Weight of cement = 370 kg/m3
Weight of coarse aggregate = 911.24 kg/m3
Weight of fine aggregate by absolute volume method

Ingredients	Weight in kg/m3	Absolute Volume
Cement	370	370x103/3.15
Coarse Aggregate	911.24	911.24x103/2.89
Water	185	185x103
		Total = 617.76x103

Absolute volume of fine aggregate = (1000-617.76)x103
= 382.24x103
Weight of fine aggregate = 2.63 x 382.24
= 100
Density of concrete is 2355 kg/m3 as against 2355 as read from table 6.
Step 8:- Mix proportions

Material	Cement	Fine Aggregate	Coarse Aggregate	Water
Quantity	370	1005.29	911.24	185
Proportions	1	2.71	2.46	0.5

For M30 grade Concrete
Input Data
Characteristic strength of concrete - 30 N/mm2
Maximum size of coarse aggregate - 20 mm
Degree of quality control - Good
Type of exposure - Mild
Specific gravity of cement - 3.15
Specific gravity of coarse aggregate - 2.89
Specific gravity of fine aggregate - 2.63
Slump - 50 mm
Dry rodded bulk density of coarse aggregate - 1437.3 kg/m3
Fineness modulus of fine aggregate - 2.66

Step 1:- Calculation of Average design strength
= fck + t × s
[As per IS 10262 – 1982, cl- 2.2, page 56]
From table 2, for 1 in 30, t= 1.65
From table 1, for good quality control and M30 concrete s = 6 N/mm2
Thus = 30+1.65x6 = 39.9 N/mm2

Step 2:- Water Cement Ratio
The w/c for design strength of 39.9 N/mm2 is 0.43
Referring to table 4, w/c corresponding to I a is 0.5
The least w/c among the two values is 0.43

Step 3:- Determination of Water content
For non- air entrained concrete containing 20 mm aggregate, water content is 185 kg/m3

Step 4:- Determination of Cement content
w/c =0.43
water = 185 kg/m3
Cement = 185/0.43 = 430.2 kg/m3

Step 5:- Weight of coarse aggregate
From table 2, for 20mm coarse aggregate and fine aggregate of fineness modulus 2.66, the bulk volume of rodded coarse aggregate per unit volume of concrete is 0.634
Density of Coarse aggregate = 1437.3 kg/m3

Weight of coarse aggregate = 1437.3 x 0.634 = 911.24 kg/m3
Step 6:-Density of fresh concrete
For 20 mm aggregate and for non-air entrained concrete, the first estimate of density of fresh concrete = 2355 kg/m3

Step 7:- Weight of ingredients of concrete
Weight of water = 185 kg/m3
Weight of cement = 430.2 kg/m3
Weight of coarse aggregate = 911.24 kg/m3
Weight of fine aggregate by absolute volume method

Ingredients	Weight in kg/m3	Absolute Volume
Cement	430.2	430.2x103/3.15
Coarse Aggregate	911.24	911.24x103/2.89
Water	185	185x103
	Total	= 636.88x103

Absolute volume of fine aggregate = (1000-636.88) x103

METHOD	M20	M30
ACI	1:1.547:3.145:0.5	1:2.21:2.11:0.43

= 363.12x103
Weight of fine aggregate = 2.63 x 363.12 = 955 kg/m3
Adding all quantities = 430.2+ 185+ 911.24+ 955Density of concrete is 2481.44 kg/m3 as against 2355 as read from table 6.

Step 8:- Mix proportions
Table : Mix Ratios and Material contents for M20,M30

3.8 TESTS ON FRESH CONCRETE

3.8.1 General

Fresh concrete or plastic concrete is a freshly mixed material which can be moulded into any shape. The relative quantities of cement, aggregates and water mixed together, control the properties of concrete in the wet state as well as in the hardened state. The following tests were conducted to evaluate the degree of workability.

3.8.2 Slump Value

Slump test was used to determine the workability of fresh concrete. Slump test as per IS 1199: 1959 is followed. The apparatus used for doing slump test were slump cone and tamping rod. The internal surface of the mould was thoroughly cleaned and freed from superfluous moisture and adherence of any old set concrete before commencing the test. The mould was then filled in four layers, each 1/3 of the height of the mould, each layer being tamped 25 times with a standard tamping rod taking care to distribute the strokes evenly over the cross section. After top layer had been rodded, the concrete was struck off level with a trowel and tamping rod. The mould was removed from the concrete immediately by raising it slowly and carefully in a vertical direction. This allowed concrete to subside. This subsidence was referred as slump of concrete. The difference in level between the height of the mould and that of the highest point of the subsided concrete was measured. This difference in height in mm was taken as slump of concrete.

3.9 TESTS ON HARDENED CONCRETE

3.9.1 General

One of the purposes of testing hardened concrete is to confirm that the concrete used at site has developed the required strength. Testing of hardened concrete plays an important role in controlling and confirming the quality of cement concrete works. Systematic testing of raw materials, fresh and hardened concrete are inseparable part of any quality control programme for concrete, which helps to achieve higher efficiency of the material used and greater assurance of the performance of the concrete with regard to both strength and durability. The test methods should be simple, direct and convenient to apply. The concrete was cast and the tests for hardened concrete such as compressive strength, split tensile strength and flexural strength were done.

3.9.2 Compressive Strength

The compressive strength test for cubes was conducted in compression testing machine as per IS 516 : 1964. The cubes were tested in compressive testing machine at the rate of 140 kg/cm2/min and the ultimate loads were recorded.
The bearing surface of machine was wiped off clean and the surface of the specimen was cleaned. The specimen was placed in machine in such a manner, load was applied to opposite sides of the cubes such that casted side of specimen was not top and bottom. The axis of the specimen was carefully aligned at the centre of loading frame. The load applied was increased continuously at a constant rate until the resistance of the specimen to the increasing load breaks down and no longer can be sustained. Maximum load applied on specimen was recorded.

Fig 3.4 Experimental Setup for Compressive Strength Test

3.9.3 Split Tensile Strength

The split tensile strength test for cylinders was carried out as per IS 516 : 1964. This test was carried out by placing a cylinder specimen horizontally between the loading surfaces of a universal testing machine and the load was applied until failure of the cylinder along the vertical diameter. When the load was applied along the generatrixan element on the vertical diameter, the cylinder is subjected to a horizontal stress and the split tensile strength was found using subsequent formula.
Split tensile strength, fcr (N/mm2) = $2P/\pi LD$
Where,
P = Ultimate load (N)
L = Length of cylinder (mm)
D = Diameter of cylinder (mm)

Fig 3.5 Experimental Setup for Split-tensile Strength Test

3.9.4 Modulus of Rupture

Flexural strength is the ability of a beam or slab to resist failure in bending. It was measured by loading un-reinforced concrete beams with a span three times the depth (usually 100 x 100 x 500 mm). The flexural strength is expressed as

"Modulus of Rupture" (MR) in N/mm2. Flexural Modulus of Rupture is about 12 to 20 percent of compressive strength. However, the best correlation for specific materials was obtained by laboratory tests.

The modulus of rupture was calculated as follows

R = PL/bd2

Where,

P = maximum load in N
L = span length in metre
b = average width in metre
d = average depth in metre

Fig 3.6 Experimental Setup for Modulus of Rupture Test

3.9.5 Flexural Strength

The flexural tests were carried out on beam specimens under standard two points loading was done confirming to IS516-1959 (Reaffirmed-1999). The flexural strength was determined by testing standard test specimens of 150mm × 300mm × 1500mm under two pint loading. Load vs. deflections measurement were observed. The ultimate load at failure was noted. Stiffness at yield load and ultimate load were determined. Deflection ductility was also calculated.

3.9.6 Ultra Sonic Pulse Velocity Method

This test is done to assess the quality of concrete by ultrasonic pulse velocity method as per IS 13311 (Part 1) – 1992. The underlying principle of this test is; the method consists of measuring the time of travel of an ultrasonic pulse passing through the concrete being tested. Comparatively higher velocity is obtained when concrete quality is good in terms of density, uniformity, homogeneity etc.

Procedure

- Preparing for use: Before switching on the "V" meter, the transducers should be connected to the sockets marked "TRAN" and "REC".
  The V meter may be operated with either:
  (a) The internal battery
  (b) The external battery
  (c) The A.C line
- Set reference: A reference bar is provided to check the instrument zero. The pulse time for the bar is engraved on it. Apply a smear of grease to the transducer faces before placing it on the opposite ends of the bar. Adjust the 'SET REF' control until the reference bar transit time is obtained on the instrument read out.
- Range selection: For maximum accuracy, it is recommended that 0.1 microsecond range be selected for path length up to 400 mm.
- Pulse velocity = (Path length/Travel time)

Table : Quality of concrete based on UPV

PULSE VELOCITY	CONCRETE QUALITY
□ 40 Km/s	Very good to excellent
3.5 – 4 km/s	Good to very good, slight porosity may exist
3 – 3.5 km/s	Satisfactory but loss of integrity is suspected
< 3 km/s	Poor and loss of integrity exist

3.9.6 PULL OUT TEST

The pull out specimens shall be casted as per IS 2770 (Part 1) and IS 1786 for evaluating their bond behaviour. Pull out tests are characterized because the concrete surrounding the embedded steel bar is being compressed during pull out contrary to the actual loading situations encountered in service, especially in flexural members. According to the codal provisions, pull out specimens of size 150 x 150 mm were cast with the diameter of rebar as 16mm.

Bond stress is calculated as,

Bond stress = (Bond stress/Embedded area of the rebar)

CHAPTER 4
RESULTS AND DISCUSSION

4.1 ONSHORE MARINE SAND

The results of the investigation carried out for finding the optimum percentage of onshore marine sand by determining the mechanical properties of concrete were as mentioned below in table 4.1.

Table 4.1 Test Results for M30 Concrete with Replacement of Fine Aggregate with Onshore Marine Sand from 10% to 50% with 2.5 % of TSE

Sl. No	Description	M30	Percentage of OSMS				
			10%	20%	30%	40%	50%
1	Slump value	80	76	73	69	65	61
2	Average 7th day compressive strength of cubes (N/mm2)	31.30	32.66	33.28	33.25	30.59	28.66
3	Average 28th day compressive strength of cubes (N/mm2)	42.22	43.60	44.20	44.30	41.77	40.88
4	Average split-tensile strength of cylinders (N/mm2)	3.89	3.91	3.96	3.97	3.88	3.81
5	Average modulus of rupture of prisms (N/mm2)	4.27	4.30	4.39	4.40	4.28	4.21

4.1.1 Slump Value

From table 4.1, it was observed that the slump value decreased with increase in percentage of OSMS. The graphical representation is shown in figure 4.1.

Fig 4.1 Variation of Slump Value for M30 Concrete with Replacement of Fine Aggregate with OSMS from 10% to 50% with 2 % of TSE

4.1.2 Compressive Strength

From table 4.1, it was observed that, average compressive strength at 7 days and 28 days increased with increase in percentage of OSMS up to 30% and then decreased for 40% and 50%. The graphical representation of the variation of average compressive strength at 7 days and 28 days is shown in figure 4.2.

Fig 4.2 Variation of Compressive Strength at 7 and 28 days for M30 Concrete with Replacement of Fine Aggregate with OSMS from 10% to 50% with 2.5 % of TSE

4.1.3 Split-Tensile Strength

From table 4.1, it was observed that, average split-tensile strength at 28 days increased with increase in percentage of OSMS up to 30% and then decreased for 40% and 50%. The graphical representation of the variation of average split-tensile strength at 28 days is shown in figure 4.3

Fig 4.3 Variation of Split-Tensile Strength at 28 days for M30 Concrete with Replacement of Fine Aggregate with OSMS from 10% to 50% with 2.5 % of TSE

4.1.4 Modulus of Rupture

From table 4.1, it was observed that, average modulus of rupture at 28 days increased with increase in percentage of OSMS up to 30% and then decreased for 40% and 50%. The graphical representation of the variation of average modulus of rupture at 28 days is shown in figure 4.4.

Fig 4.4 Variation of Modulus of Rupture at 28 days for M30 Concrete with Replacement of Fine Aggregate with OSMS from 10% to 50% with 2.5 % of TSE

From table 4.1 and figure 4.2, 4.3 and 4.4, it was observed that in the percentage of OSMS between 10% and 25%, the strength was found to be optimum. The strength was found to be increased up to 30% and then decreased for 40% and 50% because of high water absorption capacity of OSMS. Hence, the mechanical properties were again found by replacing the fine aggregate with 15% OSMS and the optimum percentage of OSMS was found as 15%.

4.1.5 Ultra sonic pulse velocity Test

4.1.5.1 Concrete made with Onshore Marine Sand

Table 4.7 Comparison of Ultrasonic pulse velocity readings at different percentages of on shore marine sand

Percentage of onshore marine sand	Ultra sonic pulse velocity (m/s)
0%	4220
5%	4110
10%	4300
15%	4225
20%	4240
25%	4280

4.1.5.1 Concrete made with Onshore Marine Sand & Tamarind Seed Extract

Percentage of TMS extract added	USPV reading (m/s)
1%	4420
1.5%	4480
2%	4600
2.5%	4410
3%	4467

4.1.6 PULL OUT TEST

4.1.6.1 Average bond stress values of corroded specimens of 15x15x15 cm cubes made with 10x10x10 cm concrete and covered with mortar.

Table 4.10 average bond stress values for concrete with mortar as cover

AVERAGE BOND STRESS VALUES

Description	Weight loss (%)	0..25 mm slip	BOND STRESS Mpa 0.25 mm slip
Corroded	1.2	17.1	27.2
Corroded	2.5	17.5	25.1
Corroded	4.2	18.8	24.1

4.1.6.2 Average bond stress values of corroded specimens of 15x15x15 cm cubes made with 10x10x10 cm concrete and covered with mortar of 2% TSE & 15% OSMS

Table 4.11 average bond stress values for concrete with mortar as cover with mortar of 2% TSE & 15% OSMS

AVERAGE BOND STRESS VALUES

Description	Weight loss (%)	0..25 mm slip	BOND STRESS Mpa 0.25 mm slip
Corroded	0.86	26.8	33.6
Corroded	1.5	27.5	35.8
Corroded	2.4	29.4	36.2

CHAPTER 5
SUMMARY AND CONCLUSIONS

5.1 SUMMARY

In this project, the mix design for control concrete grade of M30 had been designed. Concrete using OSMS and optimum amount of TSE can help in reducing the overall cost of the construction. Also the over exploitation of river sand can be brought down to a large extend

5.2 CONCLUSIONS

From the test results observed, the following conclusion had been drawn:

- The optimum percentage of onshore marine sand for maximum strengths (compressive, split-tensile and modulus of rupture) was found to be 25% for M30 grade of concrete.
- As the percentage of OSMS increased, the slump value decreased.
- The optimum dosage of TSE with 15% OSMS for maximum strengths (compressive, tensile and modulus of rupture) was found to be 2.5% for M30 grade of concrete.
- As percentage of TSE increased, slump increased for M30 grade of concrete.
- The water absorption percentages also revealed similar results.
- Ultrasonic pulse velocity measurement proved that mortar made with 15% dredged marine sand containing 2% TSE is very good and excellent and specimens are less corrosion prone.
- The pull out tests conducted for concrete specimens covered with mortar made with 15% dredged marine sand containing 2% tamarindus seed extract showed better results with higher bond strength, when compared to concrete made with mortar composed of fine aggregate only.
- As green admixture is used, it is environment friendly.
- With low water cement ratio the strength is increased.

5.3 SCOPE FOR FURTHER STUDIES

This project was carried out for onshore marine sand for M30 grade concrete and TSE as corrosion inhibitor. Future work can be carried for differently salt concentrated marine sand and different natural corrosion inhibition agents for higher grades of concrete.

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