Physical Properties of High performance Concrete using Calcium Nitrate and Polypropylene Fiber in Marine Sand

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***Abstract*:-** This paper generalized the result of study on Marine sand based High performance concrete. The Land Reclamation and Development Board (Sri Lanka) plans to popularize the use of sea sand as an alternative to river sand. According to the experts in the global construction trade, Sea sand is being used in the construction industry in the Asian Region and some leading European countries. This study is to experiment the suitability to use beach/sea sand as a substitute for river sand as fine aggregate for concrete. The attempt has been made to find the various results by using Washed sea sand and polypropylene fiber with normal concrete of M_{60} grade with maintaining the water cement ratio of 0.32.The objective of this study is to develop concrete with good strength and to protect the rebar against corrosion due to intruded chlorides from the environment or intermixed chlorides from Marine sand by using calcium nitrate. For this purpose, the experiment is carried out on M_{60} grade of concrete using marine sand, 3.5% of calcium nitrate and different percentages (0%, 0.5%, 1%, 1.5% and 2%) of polypropylene fiber to the weight of cement. Higher grade concrete is produced by adding polypropylene fiber and calcium nitrate.

***Index Terms*: Calcium Nitrate, HPC, Polypropylene Fiber, Washed Sea Sand**

I. INTRODUCTION

High performance concrete is a concrete mixture, which possess high durability and high strength when compared to conventional concrete. [1] This concrete contains one or more of cementious materials such as fly ash, Silica fume or ground granulated blast furnace slag and usually a super plasticizer. It comprises of the same materials as that of the conventional cement concrete. The use of some mineral and chemical admixtures like Silica fume and Super plasticizer enhance the strength, durability and workability qualities to a very high extent.

High Performance concrete works out to be economical, even though its initial cost is higher than that of conventional concrete because the use of High Performance concrete in construction enhances the service life of the structure and the structure suffers less damage which would reduce overall costs [6]. Concrete is a durable and versatile construction material. It is not only Strong, economical and takes the shape of the form in which it is placed, but it is also aesthetically satisfying. However experience has shown that concrete is vulnerable to deterioration, unless precautionary measures are taken during the design and production [7]. For this we need to understand the influence of components on the behaviour of concrete and to produce a concrete mix within closely controlled tolerances.

Hence it has been increasingly realized that besides strength, there are other equally important criteria such as durability, workability and toughness. And hence we talk about 'High performance concrete' where performance requirements can be different than high strength and can vary from application to application [1].

High Performance Concrete can be designed to give optimized performance characteristics for a given set of load, usage and exposure conditions consistent with the requirements of cost, service life and durability. The high performance concrete does not require special ingredients or special equipment's except careful design and production. High performance concrete has several advantages like improved durability characteristics and much lesser micro cracking than normal strength concrete [4].Any concrete which satisfies certain criteria proposed to overcome limitations of conventional concretes may be called High Performance Concrete. It may include concrete, which provides either substantially improved resistance to environmental influences or substantially increased structural capacity while maintaining adequate durability. It may also include concrete, which significantly reduces construction time to permit rapid opening or reopening of roads to traffic, without compromising long-term serviceability. Therefore it is not possible to provide a unique definition of High Performance Concrete without considering the performance requirements of the intended use of the concrete.

Marine sand

Marine sand has become a potential resource capable to supplying fine aggregate material for domestic civil engineering and construction usage [3]. In addition, by using the sea sand is economic then by using river sand because the river sand is

more expensive than the use of this inappropriate sea sand. Sea sand mainly contains much salinity as sodium chloride. If the salt is not treated and sea sand mainly contain much salinity as sodium chloride.[2]If the salt is not treated and sea sand is directly utilized for civil engineering and construction concrete project, the durability of the structural may be affected and as a result the concrete might be swelling, precipitation, sulfating and other adverse consequences[5].

The main component of sand is silica (silicon dioxide, SiO2) an extremely hard and slow-wearing substance, which may have originated from soil or volcanic eruptions a million years ago. Since no carbon is found inside silica, it cannot be carbon-dated [4]. In between the sand grains, one also finds shell (calcium carbonate, CaCO3) and organic matter, which can be carbon-dated.

Objectives

- To develop a mix design for high performance concrete with various combinations of Polypropylene fiber and sea sand
- To study the Mechanical properties such as compressive strength, tensile strength, flexural behaviour of HPC.
- To determine the chloride content of marine sand.
- To conduct on workability and durability experiments on optimum HPC mixes to ascertain the suitability of HPC under various environmental conditions.

Scope of the investigation

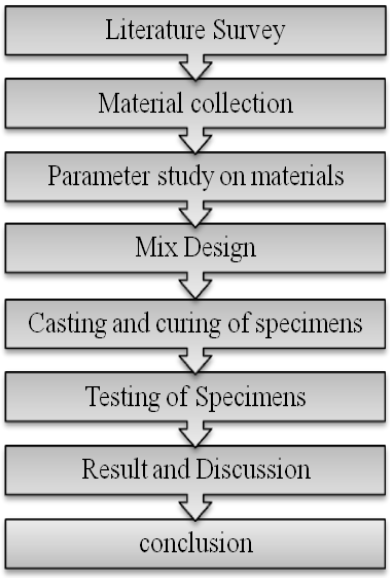
The present investigation limited to this work involved the practical study of compressive strength; split tensile and flexural strength of concrete made using sea sand as fine aggregate and addition of Polypropylene fiber (0% to 2%) at constant dosage of super plasticizers. The addition of Polypropylene fiber in which the percentage ranging from 0.5%, 1%, 1.5% and 2% yields higher compressive strength when compared to river sand and sea sand conventional mix. Beyond that there is decrease in strength for 1.5% and 2% addition of fiber in sea sand and to develop a typical HPC beam under static loading.

RESEARCH SIGNIFICANCE

Sea sand matches the requirements of workability and strength, and also the washed sea sand is ideal for concrete and plastering activities. We have studied that sea sand and river sand is used in the conventional concrete. In sea sand, limited literatures suggested that the use of polypropylene fiber and calcium nitrate in HPC. So we have decided to use the Sea Sand as a replacement for river sand and 3 - 4 % calcium nitrate of cement weight seems to be sufficient to obtain good protection of rebars in concrete to prevent corrosion.

II.METHODOLOGY

➢ The flow diagram showing the step by step procedure for the experimental work



III. MATERIAL PROPERTIES AND EXPERIMENTAL PROGRAMME

The objectives of the experimental study are given below. To study the compressive and split tensile strength behavior at 7days and 28, days form 60 grade High performance Concrete Mix.

A) Cement Ordinary Portland cement of 53 grades available in local market is used in the investigation. The cement used has been tested for various proportions as per IS 4031 – 1988 and found to be confirming to various specifications of IS 12269-1987.

Table 1: Properties of Cement

Properties of Cement	Result
Specific gravity	3.0
Fineness modulus	3.5%
Consistency	31%
Initial setting time	30 min
Final setting time	10 hrs

B) Properties of polypropylene fiber (RECRON 3S)

Table 2: Properties of Polypropylene fiber

Properties	Specification
Effective Diameter	10μ - 1.0 mm
Length	6 – 12 mm
Specific Gravity	0.91 Kg/m3
Water Absorption	Less than 0.45 %
Melting Point	Not less than 160̊ C
Aspect Ratio	12

C) Properties of Calcium nitrate

Table 3: Properties of Calcium nitrate

Properties	Specification
Density	2.50g/cm3 (anhydrous) 1.90 g/cm3 (tetrahydrate)
Solubility	Solublein ammonia almost insoluble in nitric acid
Acidity (pKa)	6.0
Flash point	Non-flammable

D) Properties of Fine aggregate

Table 4: Properties of Fine aggregate.

Comparison	River sand	Marine sand
Specific gravity	2.50	2.6
Fineness modulus	4.6	3.6
Bulk density	1792.46kg/m^3	1712.50kg/m^3

E) Properties of Coarse aggregate

Table 5: Properties of Coarse aggregate.

Specific gravity	2.63
Water absorption	0.56%
Fineness modulus	84
Bulk density	1915.2kg/m^3
Impact test	15%

F) Properties of Chloride content test

Table 6: Properties of Chloride content test.

Washed sea sand	45 ppm
Unwashed sea sand	170 ppm

IV. MIX PROPORTIONS

Mix proportions were arrived at for M60 grade of high strength self-compacting concrete. Trial mix based on the formulated mix design procedure by adding 0.5 lit of water with water-cement ratio of 0.32.

Cement	501.19 kg/m^3
Sand	616.98 kg/m^3
Coarse aggregate	1302.33 kg/m^3
Water	155.37 kg/m^3

V. RESULTS AND DISCUSSION

Experiments were conducted to study the fresh and hardened properties as well as durability aspects of HPC mixes made of washed sea sand as fine aggregate and polypropylene fiber as an admixture. This chapter deals with the results obtained and discussions from the outcome of the study.

VI.TESTS ON FRESH AND HARDENED CONCRETE

The results of fresh and hardened concrete tests were concluded on cement concrete at 28 days water curing for compressive strength, split tensile strength, flexural strength and impact resistance.

Slump

The workability of the concrete was mainly influenced by the water requirement at the time of mixing. For conventional concrete, it was mainly based on the maximum size of the aggregate used. When mineral admixture was added to the concrete, their physical characteristics mainly influenced the water demand as well workability of the mix. The slump value obtained for river and sea sand mixes are presented in table.

Table: Slump values of HPC mixes with river and washed sea sand

MIX ID	Slump value in mm
MIX RS	70
MIX SS	62
MIX 1	58
MIX 2	56
MIX 3	49
MIX 4	31

VII. Compressive and Split Tensile Strength

The Compressive and Split Tensile Strength of High Performance Concrete made up of cement with various percentages of adding Polypropylene fiber and Calcium nitrate and replacing fine Aggregate River sand with washed Sea sand. These results are given in table.

Compressive strength test

Table: Influence of River sand and washed Sea sand on Compressive and Split tensile strength of HPC

Concrete label	Compressive Strength (MPa)		Split Tensile Strength (MPa)	
	7 days	28 days	7 days	28 days
MIX RS	30.50	64.03	2.91	4.38
MIX SS	29.67	60.68	2.67	4.00
MIX 1	35.25	63.73	3.97	5.72
MIX 2	38.22	64.05	3.45	5.20
MIX 3	33.56	61.39	3.21	4.81
MIX 4	28.51	58.34	2.50	3.71

VIII. CONCLUSIONS

From the test result, the compressive strength obtained for river sand mix (MIX RS) on 28th day is greater than washed sea sand concrete mix. The compressive strength for 1% polypropylene fiber is 64.05 MPa, which is higher than the control mix (MIX RS and MIX SS). The results show that all ages, the addition of polypropylene fiber which the percentage ranging 1% yields higher compressive strength when compared to both river and sea sand conventional concrete mix. Beyond that there is decrease in strength for addition of 2% of polypropylene fiber in sea sand.

(i)Washed Sea sand based HPC has 5.5% lower compressive strength when compared to its conventional mix made of river sand.

(ii)The addition of polypropylene fiber from 0.5%, 1% and 1.5% yields higher compressive strength when compared to sea sand conventional concrete mix.

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