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PHYSICAL PROPERTIES OF HIGH PERFORMANCE CONCRETE USING CALCIUM NITRATE AND POLYPROPYLENE FIBER IN MARINE SAND

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Abstract: Traditionally, river sand has been the main source of supply but the restrictions now imposed by the Green Tribunal because of environmental degradation considerations has led to investigations into alternate sources. One such option with substantial availability could be sea sand (also known as Offshore or Marine Sand). The objective of this study is to develop concrete with high strength and to protect the rebar against corrosion due to intruded chlorides from the environment or intermixed chlorides from Marine sand. Therefore, the experiment is carried out on M70 grade of concrete with marine sand using Ground Granulated Blast furnace Slag (20% and 30% replacing cement, Micro Silica (10% replacing cement), calcium nitrate (3.5% to the weight of the cement) and polypropylene fibre (1% to the weight of the cement).

Keywords: Green Tribunal, Ground Granulated Blast furnace Slag, compressive strength, polypropylene fibre

1. INTRODUCTION

The construction industry is growing with major trust on infrastructure and the demand for sand is also increasing. The overuse of river sand for construction has many undesirable environmental and social consequences. The natural sand deposits are depleting and illegal sand mining is becoming uncontrollable issue. In-stream sand mining has become a common practice and resulted in a mushrooming of river sand mining activities which have given rise to various problems that require urgent action by the authorities. These include river bank erosion, river bed degradation, river buffer zone encroachment and deterioration of river water quality and groundwater availability. Sand is required for development of the country, but at the same time the threats posed due to sand mining cannot be ignored. Uncontrolled illicit river sand mining creates a level of damage to rivers that are ecologically irreversible even in the long run; an urgent and sustainable solution is now needed for the affected rivers and communities. Hence decisive steps have to be taken and alternate solutions found for sand mining, without disturbing the environment.

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2. MATERIAL SELECTION AND PROPERTIES

2.1 Properties of river sand, sea sand and other sands on earth's surface.

Table 1. Chemical properties of river sand and sea sand

Elements Present	River Sand	Sea Sand
Aluminium (%)	3.96	3.26
Silicon (%)	37.8	42.75
Potassium (%)	1.20	0.97
Calcium (%)	0.87	0.73
Titanium (%)	0.20	0.43
Iron (%)	1.29	1.03
Vanadium (ppm)	49.6	63.8
Chromium (ppm)	69.1	37.1
Manganese (ppm)	246.8	215
Cobalt (ppm)	4.4	3.5
Nickel (ppm)	27	18.7
Zinc (ppm)	27.6	24.3

Table 2. Physical Properties of River Sand and Sea Sand

Parameter	River sand	Marine sand
Specific gravity	2.50	2.6
Fineness modulus	4.6	3.6
Bulk density	1792.46kg/m3	1712.50kg/m3

2.2 Ground Granulated Blast Furnace Slag (GGBS)

Table 3. Physical properties of GGBS %

Colour	off white
Specific gravity	2.9
Bulk density	1200 Kg/m3
Fineness	350 m2 /kg

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2.3 Silica Fume

Table 4. Physical properties of Silica fume

Specific gravity	2.2
Mean grain size (μm)	0.15
Specific area cm2 /gm	150000- 300000
Colour	Light to Dark Grey

2.4 Calcium Nitrate

Table 5. Properties of Calcium nitrate

PROPERTIES	SPECIFICATION
Density	2.50g/cm3 (anhydrous) 1.90 g/cm3 (tetrahydrate)
Solubility	Soluble in ammonia almost insoluble in nitric acid
Acidity (pka)	6.0
Flash point	Non-flammable

2.5 POLYPROPYLENE FIBER

Figure 1. Samples of polypropylene Fiber

Table 6. Properties of Polypropylene Fibers

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 1 0 C
Aspect Ratio	12

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3. TEST FOR CONCRETE

3.1 FLEXURAL STRENGTH TEST

Flexural test evaluates the tensile strength of concrete indirectly. Figure 2 shows the comparison values of the flexural strength test result. It tests the ability of unreinforced concrete beam or slab to withstand failure in bending. Our objective in this methodology is to determine the Flexural Strength of Concrete, which comes into play when a road slab with inadequate sub-grade support is subjected to wheel loads and there are volume changes due to temperature / shrinking

FLEXURAL STRENGTH= PL/ BD2

Where,

p = flexural load (kn)
l = length of beam (mm)
b = breadth of beam (mm)
d =depth of beam (mm)

Table 7. Comparison of flexural strength test of mix 1 and mix 2 for 7, 14 and 28 days

CONCRETE MIX	FLEXURAL STRENGTH TEST (N/MM2)		
	7 DAYS	14 DAYS	28 DAYS
MIX 1	5.25	5.49	6.35
MIX 2	5.73	5.86	6.79

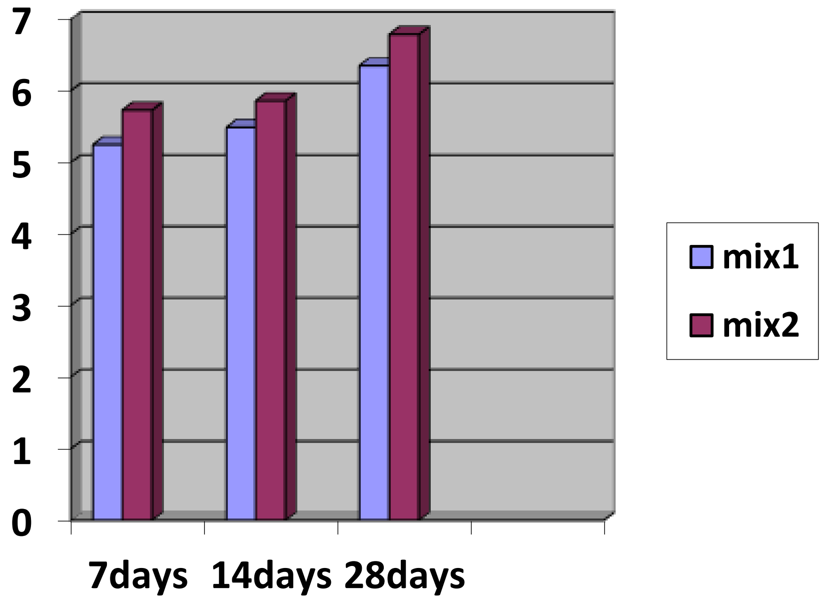

Figure 2. Flextual strength comparison for mix 1 and 2

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3.2 Compressive Strength Test

The test piece, usually in the form of a cube, prism, or cylinder, is compressed between the platens of a compression-testing machine by a gradually applied load. Brittle materials such as rock, brick, cast iron, and concrete may exhibit great compressive strengths; but ultimately they fracture unusual features in the type of failure. Figure 3 shows the comparison results of the compressive strength of mix 1 and mix 2

Table 8. Comparison of compressive strength test of mix 1 and mix 2 for 7, 14 and 28 days

CONCRETE MIX	COMPRESSIVE STRENGTH (N\mm2)		
	7 DAYS	14 DAYS	28 DAYS
MIX 1	55.74	64.75	72.34
MIX 2	60.44	69.92	80.58

Compressive Stress= Compressive Load (kN) /Cross Sectional Area (mm2)

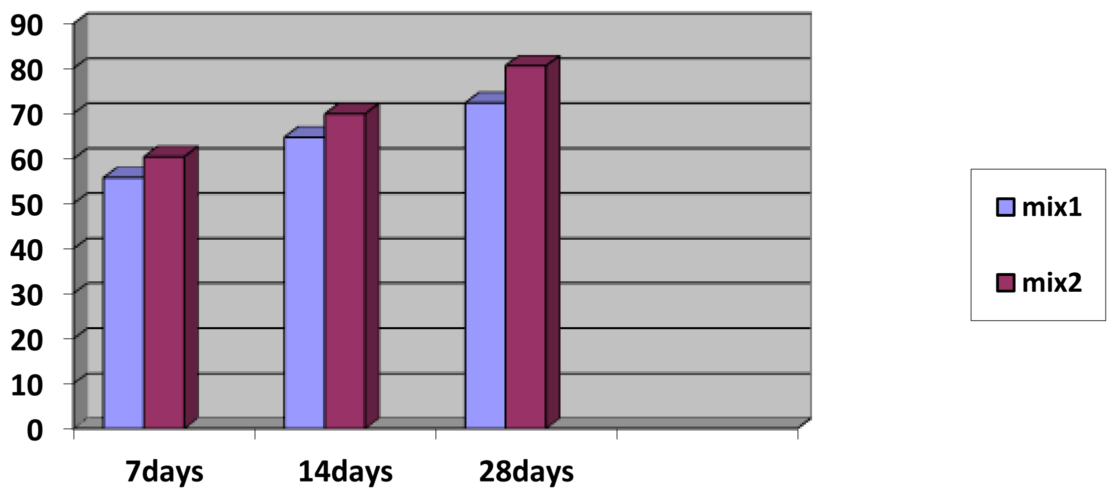

Figure 3. Comparison results of the compressive strength of mix 1 and mix 2

3.3 Split Tensile Strength Test

The tensile strength of concrete is one of the basic and important properties. Splitting tensile strength test on concrete cylinder is a method to determine the tensile strength of concrete. The concrete is very weak in tension due to its brittle nature and is not expected to resist the direct tension

$$\text{Tensile stress} = 2P/\pi DL$$

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Where,

P = Tensile Load (kN)
D = Diameter of the cylinder (mm)
L = Length of the cylinder (mm)

Figure 4 illustrates the comparison result of the compressive strength of mix 1 and mix2.

Table 9. Comparison of split tensile strength test of mix 1 and mix 2 for 7, 14 and 28 days

CONCRETE MIX	SPLIT TENSILE STRENGTH (N/mm2)		
	7 DAYS	14 DAYS	28 DAYS
MIX 1	3.08	3.55	4.32
MIX 2	3.68	3.95	4.38

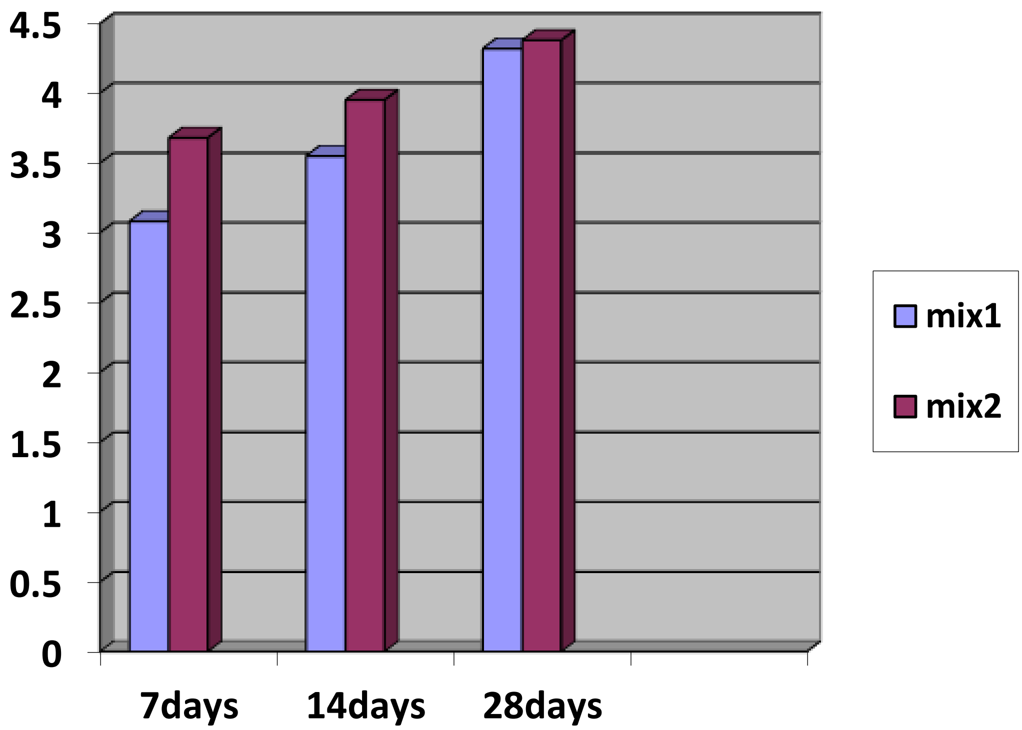

Figure 4. Comparison result of the compressive strength of mix 1 and mix2.

4. CONCLUSION

Based on the experimental work reported in this study, the following conclusions are drawn. High performance concrete of grade M70 is achieved using Washed sea, GGBS, Micro Silica, Calcium nitrate and Polypropylene fiber. The addition of Ground Granulated Blast furnace Slag of 20% yields higher Compressive, Flexural and Split tensile strength when compared to 10% addition of Ground Granulated Blast furnace Slag

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