Behavior Of Polymer Concrete With Usage Of Extra Grade Sand

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Abstract— *Concrete is most widely used construction material in the world due to its ability to get cast in any form and shape. It also replaces old construction materials such as brick and stone masonry. The strength and durability of concrete can be changed by making appropriate changes in its ingredients like cementitious material, aggregate and water and by adding some special ingredients. Hence concrete is very well suitable for a wide range of applications. Recycling waste solid materials is one of the most challenging problems worldwide with the unprecedented growth of the world population and In order to combat the scarcity of cement and the increase in cost of concrete under these circumstances the use of recycled solid wastes, agricultural wastes, and industrial by-products like used foundry sand, waste tyre rubber, fly ash, blast furnace slag, silica, rise husk came into use. Foundry sand is high quality silica sand that is a by-product from the production of both ferrous and nonferrous metal castings. The physical and chemical characteristics of foundry sand will depend in great part on the type of casting process and the industry sector from which it originates. It can be reused several times in foundries but, after a certain period, cannot be used further and becomes waste material, referred to as used or spent foundry sand.*

Keywords—polymerConcrete, extra gradesand, fly ash, blast furnace

1. INTRODUCTION:

Concrete is most widely used construction material in the world due to its ability to get cast in any form and shape. It also replaces old construction materials such as brick and stone masonry. The strength and durability of concrete can be changed by making appropriate changes in its ingredients like cementitious material, aggregate and water and by adding some special ingredients. Hence concrete is very well suitable for a wide range of applications.

Recycling waste solid materials is one of the most challenging problems worldwide with the unprecedented growth of the world population and In order to combat the scarcity of cement and the increase in cost of concrete under these circumstances the use of recycled solid wastes, agricultural wastes, and industrial by-products like used foundry sand, waste tyre rubber, fly ash, blast furnace slag, silica, rise husk came into use.

2. FOUNDRY SAND

Foundry sand is high quality silica sand that is a by-product from the production of both ferrous and nonferrous metal castings. The physical and chemical characteristics of foundry sand will depend in great part on the type of casting process and the industry sector from which it originates. It can be reused several times in foundries but, after a certain period, cannot be used further and becomes waste material, referred to as used or spent foundry sand.

Foundry sand is basically fine aggregate. It can be used in many of the same ways as natural or manufactured sands. This includes many civil engineering applications such as embankments, flowable fill, hot mix asphalt (HMA) and portland cement concrete (PCC).

At present, although a great attention to environmental issues, the general trend is still to dispose UFSs in landfills, sometimes utilised as landfill daily cover. The American Foundry Society estimates that 6.8 million tons of foundry sand (2007 data) was disposed in landfills, approximately the 2/3 of the total production. Several evident drawbacks could be listed due to this trend:

i) early closure of the material life cycle with consequently more consumption of virgin raw materials.
ii) saturation of existing landfills and soil pollution in unmanaged landfill cases.
iii) release of leachable contaminants, absorbed by the sand during the moulding process and casting
iv) operations, like heavy metals (cadmium, lead, copper, nickel, and zinc) and phenols;
v) economic impact, referring in particular to logistic costs in UFS transportation.(sometimes landfill is not so close to the foundry)

These environmental issues can be reduced to a greater extent by using the foundry sand in concrete.

3. POLYMERS

Polymer concrete is part of group of concretes that use polymers to supplement or replace cement as a binder. The types include polymer-impregnated concrete, polymer concrete, and polymer-cement concrete. Polymer concretes have rapid curing at ambient temperatures. High tensile, flexural and compressive strengths. Good adhesion to most surfaces, good long-term durability with respect to freeze and thaw cycles, low permeability to water and aggressive solutions, good chemical resistance, good resistance against corrosion,lighterweight.

Properties of Used foundry sand

Properties	Values
Specific gravity	2.80
Water absorption	3-4 %

4. EXPERIMENTAL INVESTIGATIONS
GENERAL

This chapter involves the experimental work carried out in the materials and the concrete. The beam specimen was designed and casted with various proportions of foundry sand and polymer. All the sample specimens were tested for static loading.

5. MIX PROPORTION

All the samples were prepared using design mix. The high strength concrete of M80 grade was designed as per modified ACI method. The Mix design calculation is given in Appendix A.

- Water/cement ratio - 0.38
- Mix ratios - 1 : 1.65 : 2.8

6. CASTING AND CURING

The mould is arranged properly and placed over a smooth surface. The sides of the mould exposed to concrete were oiled well to prevent the side walls from absorbing water from concrete and to facilitate easy removal of the specimen. The reinforcement cages were placed in the moulds and cover blocks were placed between cage and formwork.

As per mix proportion concrete is mixed thoroughly and placed into the mould immediately after mixing and it is compacted well using vibrators. The casting of beams are shown in Fig the test specimens were demoulded at the end of 24 hours of casting and identifications were marked. The specimens are cured in water for 28 days. After 28 days of curing the specimen was dried in air and white washed.

Fig. Casting of beams

7. TEST SETUP

Each specimen was tested under static two point loading in the loading frame. The general arrangement of the experiment setup is show in Fig. 4.4. The test was done with displacement control and specimen was subjected to displacement up to failure. By using load cell the load was precisely recorded and the beam displacement was recorded using dial gauge. A hydraulic jack was used to apply the load at the mid span of the beam in upward direction. The beams were subjected to two point loading, an I- section made of steel is placed over the beam and the load

All the specimens were tested in loading frame. The test setup is shown in Fig. 4.3. A hydraulic jack was used to apply the load at the mid span of the beam in upward direction. The beams were subjected to two point loading, an I- section made of steel is placed over the beam and the hydraulic jack is placed over the steel section for precise loading. The load is applied at a distance of 10cm from both ends.

Fig. Test setup

8. RESULTS AND DISCUSSION

Compression test :

For compressive strength test, cube specimens of dimensions (150×150×150mm) were cast using M30 grade of concrete with 3 different volumes of foundry sand and polymer to the volume of cement. After 24 hours, the specimens were demould and transferred to curing tank. After 7 & 28 days of curing, these cubes were tested on digital compression testing machine. The failure load was noted. The compressive strength was calculated as follows

A. The Percentage increase/decrease in compressive strength of concrete cube between conventional concrete and polymer concrete specimens are shown in tables.

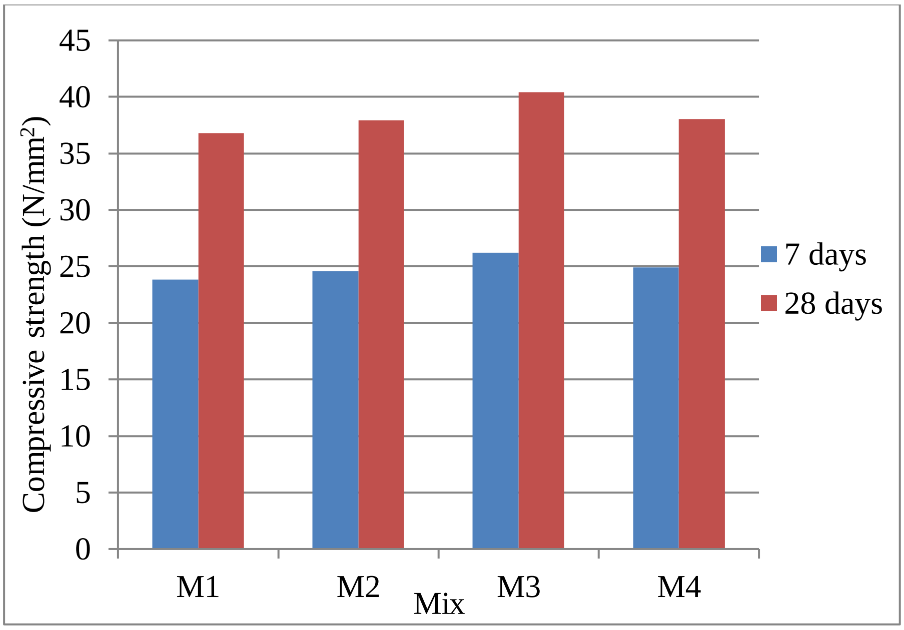

Fig. Comparison of Compressive strength

Table Percentage increase/decrease in compressive strength

Nominal Mix	Other mixes	Increase/decrease in strength (%)
Conventional Concrete mix M1	M2	+3.07
	M3	+9.86
	M4	+3.42

By comparing all the mixes, mix M3 shows the considerable increase in compressive strength when compared to conventional concrete.

Flexure Test

For flexural strength test, beams of dimensions (100× 100× 500 mm) were cast in concrete laboratory. The mould is applied with oil for lubrication. Concrete is laid in the mould in a layer up and compacted with tamping rod. In this way, the concrete is laid in and the procedure is repeated. The next step is vibration on a vibrating machine. The above procedure is the same for all the mixes with different percentage of admixture replacement. The cubes are cured for 28 days. After 28 days of curing. The beam specimens were tested in compression testing machine. For a rectangular sample under a load in a four-point bending setup where the loading span is one-third of the support span.

$$\sigma = FL / bd^2 \quad (5.1)$$

Where,

F = The load at the fracture point.

L = The length of the support span.

b = Width of the Beam in mm.

The average results of flexural strength values of the different mixes are shown in Table

Table Flexural Strength of Concrete

Concrete Type	28 days Flexural strength (N/mm^2)
M1	3.98
M2	4.13
M3	4.28
M4	4.19

The Percentage increase/decrease of flexural strength of concrete beam specimens of conventional concrete and polymer concrete specimens are shown in tables

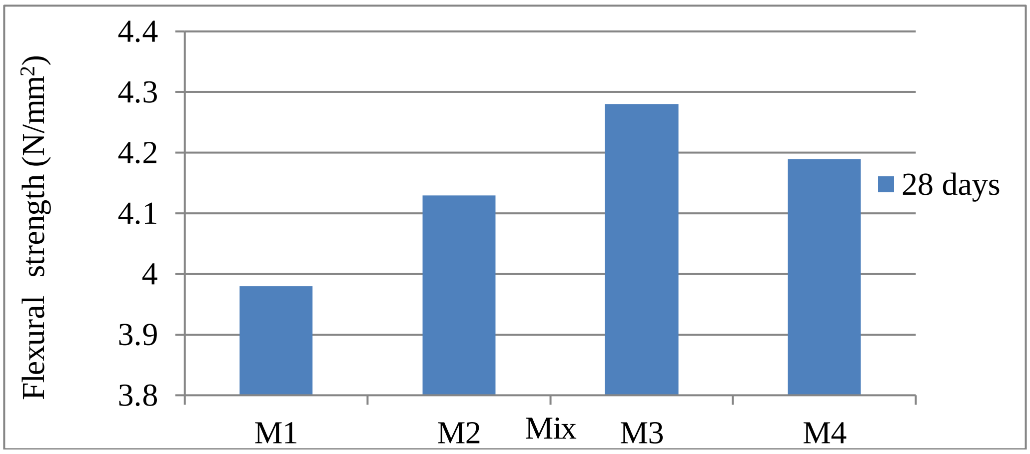

Fig. Comparison of Flexural strength

Above chart shows the comparison of strength of the different mixes

Table Percentage increase/decrease in flexural strength

Nominal Mix	Other mixes	Increase/decrease in strength (%)
Conventional Concrete mix M1	M2	+3.76
	M3	+7.54
	M4	+5.28

By comparing all the mixes, mix M3 shows the considerable increase in flexural strength when compared to conventional concrete.

Split Tensile Test

Table Split Tensile strength of concrete

Concrete Type	7 days Compressive strength (N/mm^2)	28 days Compressive strength (N/mm^2)
M1	2.55	3.03
M2	2.68	3.19
M3	2.75	3.46
M4	2.70	3.32

Above table shows that polymer concrete with 20% replacement of foundry sand shows higher results when compared to other mixes.

Table Percentage increase/decrease in split tensile strength

Nominal Mix	Other mixes	Increase/decrease in strength (%)
Conventional Concrete mix M1	M2	+5.58
	M3	+14.19
	M4	+9.57

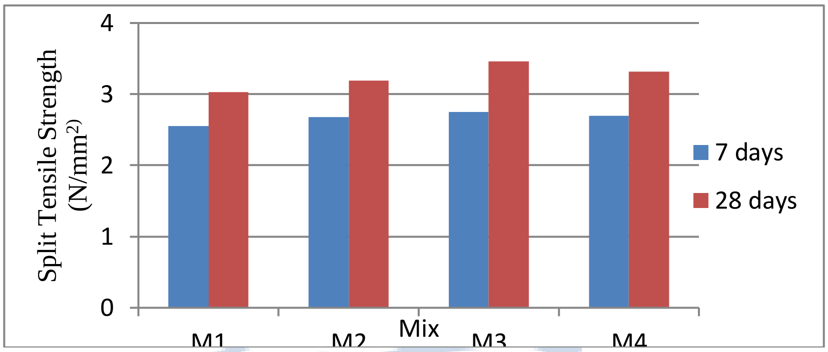

Fig.Comparison of Split tensile strength

LOAD vs DEFLECTION:

At a distance of 10 cm the load was applied at beam through the hand operated screw jack. The load cell was placed between loading point and screw jack and used to measure the applied beam forced. All specimens developed cracks at the beam bottom but suffered minor damage at the joint itself and it is observed that the ultimate deflection is around six times the yield displacement. The first crack occurred near the beam bottom and with further increase in loading, the crack propagated and initial cracks started widening. The crack pattern of the specimen will be discussed below.

Table Load vs Deflection

Load (tonne)	Deflection(mm)			
	M1	M2	M3	M4
0	0	0	0	0
0.2	0.1	0.1	0.3	0.25
0.4	0.2	0.25	0.7	0.5
0.6	0.25	0.3	1.5	1.4
0.8	0.55	0.45	2.0	1.9
1.0	0.8	0.6	2.3	2.2
1.2	1.1	0.9	2.9	3.0
1.4	1.5	1.25	3.6	3.7
1.6	2.2	2.0	4.3	4.5
1.8	2.8	2.6	5.0	5.2
2.0	3.2	3.0	5.4	5.6
2.2	3.6	3.5	6.1	6.3
2.4	3.9	3.8	6.8	7.0
2.6	4.4	4.2	7.4	7.6
2.8	5.2	5.1	8.1	8.3
3.0	5.7	5.5	8.7	9.0
3.2	6.3	6.2	9.2	9.5
3.4			10.4	10
3.6			11.2	

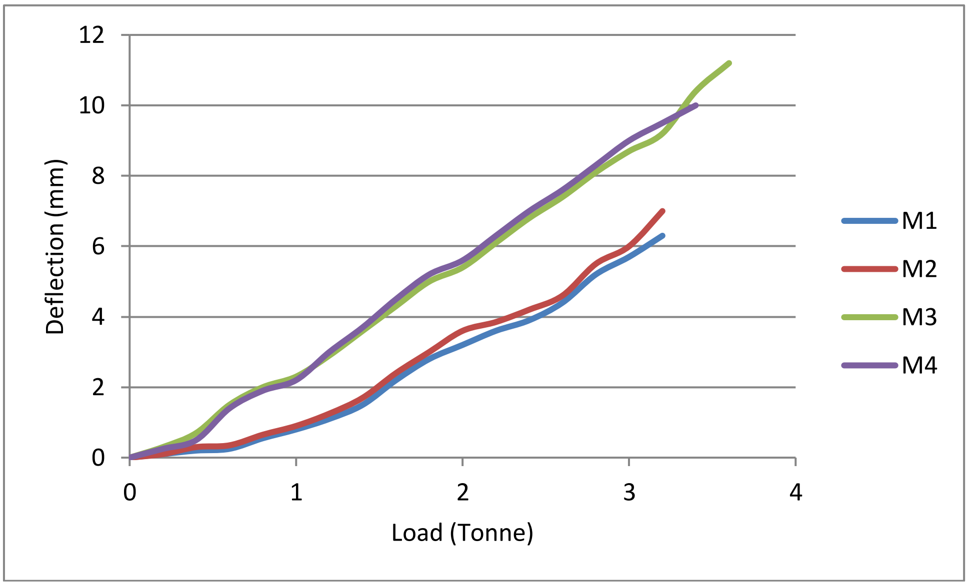

Fig. Load vs Deflection curve

The above figure shows that polymer concrete with 20% replacement of foundry sand shows higher deflection and higher load bearing capacity when compared to other mixes.

9. CONCLUSION:

In this experiment maximum compressive strength, split tensile strength and flexural strength achieved at M3 (F10P5) 10% of used foundry sand and 5% polymer.

i. The compressive strength increased by 9.86%,
ii. The split tensile strength increased by 14.19%.
iii. The flexural strength increased by 7.54%.
iv. The ultimate load strength increased by 12.54%.

The results of the present research highlights positive effects on the compressive, tensile and flexural properties of concrete containing used foundry sand and polymer cement concrete when compared to concrete mixes containing foundry sand only. However the decrease in mechanical properties with respect to OPC concrete is still evident. The effect of replacing foundry sand with fine aggregate on the compressive strength could be seen as reduced significantly by 90% when using polymer in the concrete mix. Although the strength data developed in this study (compressive strength and flexural and others (split tensile strength) indicated a systematic reduction in strength with the increase of foundry sand. Used foundry sand affects the workability of concrete and PCC fresh property. So, the replacement of foundry sand made should not be more than 20%.

Based on the results obtained, it can be concluded that structural grade concrete can be produced using used foundry sands as a partial replacement of regular concrete sand. Test data showed that the mix containing 20% used foundry sand and 5% polymer showed about 10% higher compressive strength, 14% higher split tensile strength, 7.5% higher flexural strengtth at 28 days as compared with conventional concrete.

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