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Effect of Used Foundry Sandand Pozzocrete Partial Replacement with Fine Aggregate and Cement in Concrete

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Abstract-To produce low cost concrete by blending various ratios of fine aggregate and cement with used foundry sand and Pozzocrete to reduce disposal and pollution problems due to used foundry sand and Pozzocrete.Pozzocrete P60 is a processed quality assured fly ash, investigated for its use as a partial replacement for cement in concrete (1:1.48:3.21). The utilization of Pozzocrete P60 as cement replacement material in concrete or as additive in cement introduces many benefits from economical, technical and environmental points of view. The innovative use of used foundry sand in concrete formulations as a fine aggregate replacement material was tested as an alternative to traditional concrete. This paper presents the results of the concrete of mix proportion 1:1.48:3.21 in which cement is partially replaced with Pozzocrete P60 as 10% by weight of cement, and fine aggregate is partially replaced with used foundry sand as 10%, 30% and 50% by weight of fine aggregate. Five set of mixture proportions were made. First (A0) were standard mix (without Pozzocrete and used foundry) sand with regional fine aggregate (sand)and coarse aggregate and the second (B0) mix contained 10% Pozzocrete P60obtained from DIRK India Private Limited, Nasik, Maharashtra state. Other mixes (B1, B2, and B3) contained Pozzocrete P60 (10%)plus foundry sand (10%, 30%and 50%)respectively obtained fromferrous and non-ferrous metal casting industries.The compressive strength and water absorption has been obtained with partial replacement of Pozzocrete P60 with cement and foundry sand with fine aggregate. Test results indicate the increase in the strength properties of concrete and decreasing water absorption of concrete up to 10% replacement of cement with pozzocrete plus 30% replacement of fine aggregate with used foundry sand for strength at 7, 14and 28 days. Also it can be used in non-structural elements with the low range compressive strength wherestrength is not required and low cost temporary structure is prepared.

Keywords: Pozzocrete P60,used Foundry Sand, Partial replacement,Concrete, Compressive strength, Fine aggregate, Cost.

I. INTRODUCTION

Concrete is a composite construction material composed of cement, aggregate (generally a coarse aggregate made of gravels or crushed rocks such as limestone, or granite, plus a fine aggregate such as sand), water, and/or admixtures. Concrete is made by mixing: Cement, water, course fine aggregates and admixtures (if required).

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The objectives are to mix these materials traditionally to make concrete that is easy to: Transport, place, compact, finish and to give a strong and durable product. The proportionate quantity of each material (i.e. cement, water and aggregates) affects the properties of hardened concrete.Due to the environment concern and the need to conserve energy, various research efforts have been directed toward the utilization of waste materials. The cost of cement is also steadily increasing. With ever-increasing environmental problems because of industrial waste products comes a great need to use these products in an appropriate manner to reduce health and environmental problems. For this purpose, experimental investigation is carried out to develop the data on the compressive strength and water absorption development of concrete with time and with different percent replacement of Pozzocrete P60 and used foundry sand.

The objectives of the present study are:

- To select the Pozzocrete P60 and used foundry sand mix proportion for concrete.
- To investigate change in compressive strength and water absorption of concrete with Pozzocrete P60 and used foundry sand replacement.
- To perform the experiments on the time-dependent compressive strength and water absorption of concrete with Pozzocrete P60 and used foundry sand. The strengths were measured at the age of 7, 14 and 28 days and water absorption was measured at the 28 days.

II. DESIGN MIX MATERIALS

A. Cement

The cement used is SANGHI OPC 53 grade cement. The Ordinary Portland Cement of 53 grade conforming to IS: 8112-1989is be use. Tests were conducted on cement like Specific gravity, consistency tests, setting tests, soundness,Compressive strength N/mm^2 at 28 days.

Fig 1: SANGHI OPC 53 Grade Cement

TABLE – 1

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PROPERTIES OF CEMENT

Sr. No.	Physical properties of SANGHI OPC 53cement	Result	Requirements as per IS:8112-1989
1	Specific gravity	3.15	3.10-3.15
2	Standard consistency (%)	31.5 %	30-35
3	Initial setting time (hours, min)	91 min	30 minimum
4	Final setting time (hours, min)	211 min	600 maximum
5	Compressive strength N/mm^2 at 28 days	58 N/mm^2	53 N/mm^2 minimum

B. Fine aggregate

Those fractions from 4.75 mm to 150 micron are termed as fine aggregate. The river sand is be used as fine aggregate conforming to the requirements of IS: 383. The river sand is wash and screen, to eliminate deleterious materials and over size particles.

Fig 2: Fine aggregate (River sand)

TABLE- 2
PROPERTIES OF FINE AGGREGATE

Property	Fine Aggregate (River sand)
Fineness modulus	3.1
Specific Gravity	2.767
Water absorption (%)	1.2
Bulk Density (gm/cc)	1.78

C. Water

Water is an important ingredient of concrete as it actually participates in the chemical reaction with cement. Since it helps to from the strength giving cement gel, the quantity and quality of water is required to be looked into very carefully.

D. Foundry Sand

Metalfoundriesuselargeamountsofthemetalcasting process.Foundries successfully recycle and reusethe sandmanytimesinafoundryand the remainingsand that istermed asfoundry sandisremovedfromfoundry.Thisstudypresentstheinformatio nabouthe civil engineering application soffo undry sand, which iste chnically soundand environmentally safe.Useoffoundrysandinvariousengineeringapplicationscans olvethe problemofdisposaloffoundrysandandotherpurposes. Foundrysandconsistsprimarilyofsilicasand,coatedwithathinfi lm ofburntcarbon,residualbinder(bentonite,sea coal,resins)anddust.Foundrysandcanbe usedinconcretetoimproveitsstrength and other durabilityfactors. FoundrySand can be usedasapartialreplacement ofcementorasapartialreplacementoffineaggregatesor totalreplacementoffineaggregateandassupplementary additiontoachievedifferent propertiesof concrete.

Figure: 3.Used Foundry sand

Source: foundry industry, GIDC, VallabhVidyanagar-Anand, Gujarat Source: R. Siddique, Waste Materials and By-Products in Concrete, Springer-2008

TABLE – 3
PROPERTIES OF USED FOUNDRY SAND

Constituent	Value (%)
SiO_2	87.91
Al_2O_3	4.70
Fe_2O_3	0.94
CaO	0.14
MgO	0.30
SO_3	0.09
Na_2O	0.19
K_2O	0.25
TiO_2	0.15
P_2O_5	0.00
Mn_2O_3	0.02
SrO	0.03
LOI	5.15
TOTAL	99.87

D. Pozzocrete (P60)

Pozzocrete (P60)is a high efficiency pozzolanic material, obtained by selection, processing and testing of power station fly ash resulting from the combustion of coal at electricity generating power stations.

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It is subjected to strict quality control procedures. P60 confirms to IS: 3812 part-1 fly ash for use as component of cement with Portland clinker.

TABLE- 4
GENERAL PROPERTIES OF POZZOCRETE

Property	P60
Presentation	Finely divided dry powder
Specific Gravity	2.3
Colour	Light grey
Bulk weight (tonne per m^3)	1.0 tonne per m^3
Loss on Ignition	<2.5%
Particle size	<18% retained on 45 micron sieve
Particle shape	Spherical
Package	30 kg bags, 1 tonne big-bags and bulk tankers

III. DESIGN MIX METHODOLOGY

Concrete compositions

A cement concrete mix 1:1.48:3.21 was designed as per IS: 10262:2009 methods and the same was used to prepare the test samples. The design mix proportion is done in Table 5 and 6.

TABLE - 5
M20 MIX DESIGN PROPORTIONS

	W (lit)	C (Kg/m^3)	F.A. (Kg/m^3)	C.A. Kg/m^3)
By weight, [gms]	191.60	383.21	569.38	1231.11
By volume, [m^3]	0.5	1	1.48	3.21

W= Water, C= cement, F.A. = Fine Aggregate, C.A. = Coarse Aggregate

TABLE -6
CEMENT REPLACEMENT BY POZZOCRETE ANDSAND REPLACEMENT BY USED FOUNDRY SAND

Sr. No.	Concrete Type	Description of Concrete
1	A0	Standard
2	B0	10% P60
3	B1	10%P60 + 10%FS
4	B2	10%P60 + 30%FS
5	B3	10%P60 + 50%FS

TABLE - 7
DESIGN MIX PROPORTIONS FOR M20 MIX CONCRETE

C.T.	W/C ratio	% replacement		Design Mix Proportions For M20 Concrete (1:1.48:3.21)				
		C	F.A.	C	F.A.	C.A.	U.F.S	P 60
A0	0.50	0	0	1	1.48	3.21	-	-
B0	0.50	10 %	0	0.9	1.48	3.21	-	0.1
B1	0.50	10 %	10 %	0.9	1.33	3.21	0.14	0.1
B2	0.50	10 %	30 %	0.9	1.03 6	3.21	0.44	0.1
B3	0.50	10 %	50 %	0.9	0.74	3.21	0.74	0.1

C.T. = Concrete Types,C= Cement, F.A.= Fine Aggregate, C.A.= Coarse Aggregate, U.F.S. =Used Foundry Sand

IV. EXPERIMENTAL METHODOLOGY

A. Testing methodology

The evaluation of Used Foundry Sandfor use as a replacement of fine aggregate material begins with the concrete testing. Concrete contains cement, water, fine aggregate, coarse aggregate and grit. With the control concrete, i.e. 10%, 30% and 50% of the fine aggregate is replaced with used foundry sand,the data from the used foundry sand is compared with data from a standard concrete without used foundry sand. Three cube samples were cast on the mould of size 150*150*150 mm for each 1:1.48:3.21 concrete mix with partial replacement of fine aggregatewith w/c ratio as 0.50 were also cast. After about 24 h the specimens were de-moulded and water curing was continued till the respective specimens were tested after 7,14 and 28 days for compressive strength and 28 days for water absorption tests.

B. Compressive strength

Compressive strength tests were performed on compression testing machine using cube samples. Three samples per batch were tested with the average strength values reported in this paper. The loading rate on the cube is 35 N/mm^2 per min. The comparative studies were made on their characteristics for concrete mix ratio of 1:1.48:3.21 with partial replacement of fine aggregate with used foundry sand as 10%, 30%and 50%.

Figure: 4 Setup of Compression Strength Testing Machine

C. Water Absorption Test

The cubes after casting were immersed in water for 28 days curing. They were then weighted and this weight was noted as the wet weight of the cube. These specimens were then oven dried at the temperature 185^{0}C until the mass became constant and again weighed. This weight was noted as the

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dry weight of the cube.

% Water Absorption = [(WW – DW) / DW] x 100

Where, WW = Wet Weight of Cube,
DW = Dry Weight of Cube.

IV. RESULT

TABLE -8
COMPRESSIVE STRENGTH OF CONCRETE (N/mm^2)FOR M20 MIX AT 7,14 & 28 DAYS

Types of Concrete	Average Ultimate Compressive Strength of cement concrete (N/mm^2) at 7 days	Average Ultimate Compressive Strength of cement concrete (N/mm^2) at 14 days	Average Ultimate Compressive Strength of cement concrete (N/mm^2) at 28 days
A0	13.93	20.59	24.00
B0	25.33	35.11	39.11
B1	20.15	33.33	38.22
B2	29.78	38.67	42.52
B3	24.59	34.52	36.74

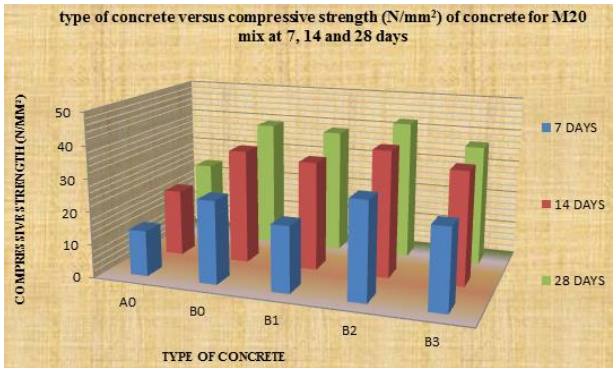

Figure: 5 Type Of Concrete V/S Compressive Strength (N/mm^2)for M20 mix at 7, 14 And 28 Days

TABLE -9
WATER ABSORPTION OF CONCRETE (N/mm^2) FOR M20 MIX AT 28 DAYS

Sr. No.	Type of Concrete	Wet Weight of Cube In Grams	Dry Weight of Cube In Grams	%Water Absorption
1	A0	8330	8485	1.86
2	B0	8467	8603	1.61
3	B1	9255	9407	1.65
4	B2	7841	7959	1.50
4	B3	8845	8997	1.71

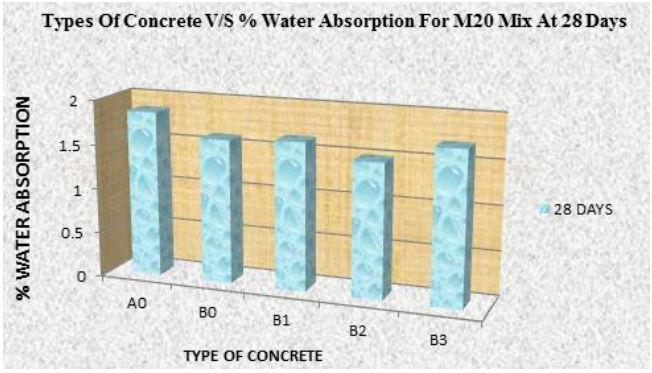

Figure: 6Types of Concrete V/S % Water Absorption for M20 Mix at 28 Days

V. ECONOMIC FEASABILITY

TABLE- 10 COSTS OF MATERIALS

Sr. No.	Materials	Rate (Rs/Kg)
1	Cement (SANGHI OPC 53 grade)	6.00
2	Fine aggregate (Regional)	0.61
3	Coarse aggregate (Regional)	0.65
4	Pozzocrete (P60)	4.40
5	Used foundry sand	0.20

TABLE - 11
TOTAL CONSUMPTION AND COST OF MATERIALS FOR M20 DESIGNE MIX CONCRETE (1:1.48:3.21) PER m^3

C.T.	Consumption of Design Mix Proportions For M20 Concrete (1:1.48:3.21)					Total Cost /m^3	% Change In Cost
	C	F.A.	C.A.	U.F.S	P 60		
A0	383.21	569.38	1231.11	-	-	3446.80	0
B0	344.89	569.38	1231.11	-	38.32	3385.48	-1.78
B1	344.89	512.44	1231.11	56.94	38.32	3362.14	-2.46
B2	344.89	398.56	1231.11	170.82	38.32	3315.44	-3.81
B3	344.89	284.69	1231.11	284.69	38.32	3268.76	-5.17

C.T. = Concrete Types,C= cement, F.A. = Fine Aggregate, C.A. = Coarse Aggregate, U.F.S. = Used Foundry sand

VI. CONCLUSION

From this study the following conclusion can be drawn:

a) The results presented in this paper, indicate that the incorporation of a 10%Pozzocrete P60 mixed cement is feasible for strength.
b) Pozzocrete P60 and foundry sandcan be used in concrete to improve strength. Partial replacement of the Portland cement with Pozzocrete P60 and Partial replacement of fine aggregate with used foundry sandimprove strength.

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c) Also, it can be used in non-structural elements with the low range compressive strength where strength is not required.

d) Pozzocrete P60 and used foundry sandcan be used to prepared low cost temporary structure.

e) The results indicate that the % change in cost reduce up to 5.17 for 50% replacement of used foundry sand plus 10% replacement of pozzocrete.

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