FEASIBILITY OF GEOPOLYMER SAND AND ARTIFICIAL SAND IN HIGH GRADE CONCRETE

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Abstract

Concrete is the most essential and utilized material in development. This investigation is carried out to study the feasibility of using locally available artificial sand & Geopolymer sand as partial replacements of sand in concrete. A concrete mix with artificial sand, Geopolymer sand & natural sand with different proportions were studied. The experimentation M40 concrete mix was designed for replacement of geopolymer sand and artificial sand for 10%-40%, 20%-30%, 30%-20%, and 40%-10% respectively and 50% natural sand was remains constant in every mix.

Key Words : Natural sand, Artificial Sand, Geopolymer sand, Compressive strength, Split tensile strength.

1. Introduction

To improve the strength economically we must improvise the use of materials that are locally available. Fly ash are waste product of power plants. Geopolymer sand. is manufactured by chemical action on fly ash.

Test were performed to study strength and durability of concrete containing artificial sand geopolymer sand and results were compared with controlled mix concrete containing 100% natural sand.

2. Materials

Cement

Ordinary Portland Cement ACC of grade 43 confirming to IS 8112: 2013 was used. The physical properties are as follows

Table 1
Physical Properties of Cement

Sr. No	Property	Value
1	Specific gravity	3.2
2	Fineness	298 m ² /kg
3	Normal consistency	32.50%
4	Initial setting time	136minute
5	Final setting time	240 minute
6	Soundness	0.80 mm

2.1 Fine Aggregate

Natural Sand was obtained from the Kanhan River and Artificial sand was obtained from Sidheshwar crusher sand,, pachgoan umred road. Nagpur Geopolymer sand was obtained from VNIT college, Nagpur. Physical properties of all three sands are listed in table 2. Sieve analysis test is given in table3

Table 2
Physical Properties of sand

Test	Natural Sand	Artificial Sand	Geopolymer Sand
Fineness Modulus	3.331	3.38	3.768
Specific Gravity	2.66	2.85	2.5
Bulking of Sand	21.499%	17.125%	19.812%
Bulk Density	1720.11 KG/M3	1895.04 KG/M3	1020.40 KG/M3
Water Absorption	1%	2.5%	5.61%

Table 3
Sieve Analysis of sand

IS Sieve Designation	Percentage Passing		
	Natural sand	Artificial sand	Geopolymer sand
4.75 mm	98.25	100	97
2.36 mm	96.25	97.5	87
1.18 mm	89.35	66	71
600 micron	71.95	48	47
300 micron	9.65	31	13.7
150 micron	1.8	19	5.5
Pan	1	0.5	2

2.2 Coarse Aggregate

Coarse aggregate of crushed natural stone were used of nominal size of 10 mm and 20 mm were widely used. Testing of physical properties of coarse aggregates was carried out as Per IS: 383-1970 and is given in table number 4. The sieve analysis of coarse aggregate is shown in table 5

Table 4
Physical Properties of Aggregate

Test	Coarse Aggregate
Fineness Modulus	8.05
Specific Gravity	2.85 g/cc
Water Absorption	3.09%

Table 5
Sieve Analysis of aggregate

IS Sieve designation	Percentage passing
40 mm	98
20 mm	96
10 mm	0.6
4.75 mm	0
2.36 mm	0
1.18 mm	0
600 micron	0
300 micron	0
150 micron	0

2.3 Geopolymer sand

Geopolymer sand is nothing but a chemically treated fly ash which was obtained from V.N.I.T Nagpur. Geopolymer sand was grey in colour, perfectly graded, light weighted as compared to natural sand & artificial sand. The specific gravity of Geopolymer sand is lower and the water absorption was higher than natural sand & artificial sand

2.4 Artificial Sand:

Quarry Sand was obtained from Siddheshwar quarry, Pachgaon. Plant: 360, Surgaon, Nagpur. The least

expensive and the most effortless method for getting substitute for artificial sand is by crushing normal stone to get sand of required size and grade which would be free from all contaminations is known as Artificial Sand.

2. Concrete Mix Design

Concrete mix was designed with IS 10262-2009 and IS 456-2000 assuming good quality control and moderate exposure conditions. The mixes were designed for M40 grade with 50% natural sand constant in every mix and artificial sand and geopolymer sand of 10%-40%, 20%-30%, 30%-20%, and 40%-10% respectively. To restrict water-cement ratio up to 0.50 and to get workability super plasticizer was used as a admixture. Plasticizer was used in percentage with cement weight. The adopted mix proportions are given in table 6 below.

Table 6
Mix Proportion of concrete Mixes

Material (Kg/m ³)	10%-G.S 40% A.S	20%-G.S 30% A.S	30%-G.S 20% A.S	40%-G.S 10% A.S	100% N.S
Cement	400	400	400	400	400
Natural sand	338.06	338.06	338.06	338.06	675.61
Geopolymer Sand	60.62	121.25	181.87	242.49	-
Artificial Sand	285.54	214.15	142.77	71.38	-
Coarse aggregate	1347.9	1347.9	1347.9	1347.9	1347.9
Water	165.19	166.96	168.73	170.51	157.68
Super plasticizer	4	4	4	4	4
Water / Cement ratio	0.41	0.417	0.42	0.429	0.39

3. Experimentation

Casting of cubes and cylinders were done by weight batching method. The exact amount of materials were weighted and mixed in a concrete mixer. Standard mould cubes of size 150 mm and Cylinders of size 150 mm diameter and 300 mm in height were used for compressive strength, split tensile strength and that were determined after 28 days and 56 days curing. The results are tabulated in table 7 and table 8 and table 9. Durability tests were carried out by acid attack test, Ph value test and results are given in table no 10., 11, 13, 14

Table 7
Compressive Strength of concrete

Days	Compressive Strength (N/mm ²)				
	10%-G.S 40% A.S	20%-G.S 30% -A.S	30%- G.S 20% A.S	40%- G.S 10% A.S	100% N.S
28	41.775	54.665	42	44.44	43.11
56	44.665	43.33	43.55	45.776	43.55

Table 8
Split Tensile strength of concrete

Type of Mix	Tensile Strength N/mm ²
100% NS	3.94
10% G.S 40% A.S	3.715
20% G.S 30% A.S	3.815
25% G.S 35% A.S	3.748
30% G.S 20% A.S	3.88
40% G.S 10% A.S	3.53

Table 9
Bond strength of concrete

MIX TYPE (M40)	STRENGTH (N/mm ²)
100% NS	3.87
10% GS 40% CS	8.435
20% GS 30% CS	9.018
25% GS 25% CS	8.647
30% GS 20% CS	8.594
40% GS 10% CS	9.177

DURABILITY TEST

Acid Attack Test

Table 10
Loss of weight after immersion in H₂SO₄ water solution

MIX TYPE (M40)	Weight Before (Kg)	Weight After (Kg)	Loss Percentage (%)
100% NS (Mix 1)	8.41	7.79	7.37
10% GS 40% CS (Mix 2)	8.34	7.665	8.09
20% GS 30% CS (Mix 3)	8.18	7.5	8.31
30% GS 20% CS (Mix 4)	8.26	7.47	9.56
40% GS 10% CS (Mix 5)	8.36	7.865	5.92

Table 11
Loss of weight after immersion in HCl water solution

MIX TYPE (M40)	Weight Before (Kg)	Weight After (Kg)	Loss Percentage (%)
100% NS (Mix 1)	8.41	8.03	4.51
10% GS 40% CS (Mix 2)	8.34	7.98	4.31
20% GS 30% CS (Mix 3)	8.18	8.105	0.91
30% GS 20% CS (Mix 4)	8.26	8.17	1.08
40% GS 10% CS (Mix 5)	8.36	8.225	1.61

Table 12
pH of Concrete in H₂SO₄ Water solution

MIX TYPE (M40)	Before immersion	After immersion
100% NS	12.52	11.77
10% GS 40% CS	12.431	11.5
20% GS 30% CS	12.556	11.81
30% GS 20% CS	12.397	11.54
40% GS 10% CS	12.453	11.78

Table 13
pH of Concrete in HCl Water Solution

MIX TYPE (M40)	Before immersion	After immersion
100% NS	12.52	11.58
10% GS 40% CS	12.431	10.91
20% GS 30% CS	12.556	11.14
30% GS 20% CS	12.397	10.63
40% GS 10% CS	12.453	10.54

Table 14
Loss of strength in H₂SO₄ water solution

MIX TYPE (M40)	strength (N/mm ²)	Loss Percentage (%)
100% NS (Mix 1)	18.88	56.2
10% GS 40% CS (Mix 2)	16.67	60.09
20% GS 30% CS (Mix 3)	23.55	56.91
30% GS 20% CS (Mix 4)	20	52.38
40% GS 10% CS (Mix 5)	20.67	53.48

Table 15
Loss of strength for HCl water solution

MIX TYPE (M40)	strength (N/mm ²)	Loss Percentage (%)
100% NS (Mix 1)	30.67	28.85
10% GS 40% CS (Mix 2)	41.11	1.59
20% GS 30% CS (Mix 3)	40.44	26.02
30% GS 20% CS (Mix 4)	30.44	27.52
40% GS 10% CS (Mix 5)	32.67	26.48

4. Conclusion

- When natural sand is replaced by geopolymer sand and artificial sand, the requirement of water is increased as the water absorption of these two sands is higher than natural sand.
- Geopolymer sand and artificial sand can be used to replace natural sand as a fine aggregate as its compressive strength is more than mix with 100% natural sand.
- The split tensile strength was less for critical mix as compared to controlled mix.
- The bond strength of mix with combination of geopolymer sand and artificial sand with natural sand has good strength when compared to mix with 100% natural sand.
- Mix having 10% geopolymer sand and 40% artificial sand were least affected by HCL acidic solution
- Attack was severe on concrete as the pH of water solution of H₂SO₄ and HCl get decrease..
- Durability point of view natural sand can be replaced with geopolymer sand and artificial sand.
- When pH were compared, the effect of HCl acidic solution was more as compared to H₂SO₄ acidic solution. It has been observed that pH of concrete immersed in HCl water solution get more affected as compared to concrete immersed in H₂SO₄ solution. The most affected concrete were mix having 40% geopolymer sand and 10% artificial sand

References

- [1] Bureau of Indian Standards, IS 456-2000, "Plain and Reinforced Concrete- Code of Practice", 2000, New Delhi
- [2] Bureau of Indian Standards, IS 516-1959, "Method of test for strength of concrete", 1959, New Delhi
- [3] Bureau of Indian Standards, IS 10262-2009, "Recommended guideline for concrete mix design", 1982, New Delhi
- [4] Bureau of Indian Standards, IS 1199- 1959, "Method of sampling and analysis of concrete", 1959, New Delhi
- [5] Bureau of Indian Standards, IS 5816- 1999, "Splitting tensile strength of concrete method of test", 1999, New Delhi
- [6] Bureau of Indian Standards, IS 383- 1970, "Specification for coarse and fine aggregate from natural source of concrete", 1970, New Delhi
- [7] R. S. Patil, H.N. Rajakumara and Rudraswamy M.P., ISSN :2347-2812, 2016, "Effect of Replacement of Natural Sand by Blends of Fly Ash and Bottom Ash on Properties of Concrete"
- [8] Harshlata R. Raut, Ashish B. Ugale, 2016, "Effect of Artificial Sand on Compressive Strength and Workability of Concrete"
- [9] Jerusha Susan Joy, Mini Mathew, 2015 "Experimental study on geopolymer concrete with partial replacement of fine aggregate with foundry sand"
- [10] M. R. Chitlange, P. S. Pajgade, Ram Meghe and P. B. Nagarnaik, International Journal of Advanced Technology in Engineering and Science, September 2015, "Experimental Study of Artificial Sand Concrete"
- [11] Rajendra P. Mogre and Dhananjay K. Parbat, International Journal of Civil, Structural, Environmental and Infrastructure Engineering Research and Development (IJCSEIERD) ISSN(P): 2249-6866; ISSN(E): 2249-7978, Dec 2013 "Optimum replacement of natural sand with artificial sand in concrete"
- [12] Palash Ashok Khanorkar, Pawan Madhukar Aglawe, Arjun Anil Khadse, and Prakash S. Pajgade, International Conference on Science and Technology for Sustainable Development (ICSTSD)- 2016, "Replacement of conventional Sand by Artificial Sand in Concrete"
- [13] Akshay A. Waghmare, Akshay G. Kadao, Ayushi R. Sharma and Sunil G. Thorve, "Study of Replacement of Natural Sand by Artificial Sand in Concrete" International Conference on Electrical, Electronics, and Optimization Techniques
- [14] Janani R, Revathi A, "Experimental Study of Geopolymer Concrete with Manufactured Sand" International Journal of Science, Engineering and Technology Research (IJSETR), April 2015
- [15] A. D. Pofale, S. V. Deo, "A Study of Fine Aggregate Replacement with Fly Ash: An Environmental Friendly and Economical Solution", Visvesvaraya National Institute of Technology, Nagpur, National Institute of Technology, Raipur.