Concrete Made By Paper Sludge

[1]Mohitsinh Arvindsinh Rajavat, [2]Ajaysinh Bharatsinh Jadeja, [3]Megha Deval Vasavada
[1]Student, [2]Student, [3]Temporary Assistant Professor
The Maharaja Sayajirao University Of Baroda

***Abstract* - To produce low-cost concrete by blending various ration of cement with paper sludge and to reduce disposal and pollution problems due to paper sludge. It is most essential to develop profitable building materials from paper sludge. Innovative use of paper sludge in concrete formation as a supplementary cementitious material was tested as an alternative to normal concrete. In this study, paper sludge was physically and chemically characterized and partially replacement in the ratio of 0%, 20 %, 30 %, 30% of paper sludge +20% of fly ash by weight of cement, natural river sand as fine aggregate, and normal coarse aggregate were used to produce concrete. Present study gives us an idea about how concrete's mechanical properties like compressive strength, split tensile test and flexural strength & fresh properties like slump behave if we replace a cement with hypo-sludge to a certain extent.**

***keywords* - concrete , hypo-sludge, compressive and flexural strength, paper waste,**

I. Introduction

Concrete is the second expensive and widely used material all over the world. Concrete is a mixture of mainly cement, aggregate, sand, and water. Cement is the most important and costly material in concrete. Today's annual cement production reach 2.8 billion tonnes. Per tonne production of cement produced 1.25 tonnes CO_2 and it's also consumes natural resources like limestone and boulder stones. As population increase, we need to find a better alternative material to replace of cement. On the other side, Paper mills generally produce a large amount of solid waste, which consumes a large percentage of landfill space for each and every year. This waste is generated in primary sedimentation tank of paper mills, it contains broken, low-quality paper fibres, which is also known as paper sludge. If the concentration of paper sludge is more then it will contaminate groundwater. Some companies burn their sludge which contributes in air pollution. As population increases natural resources get reduced to obtain cement. To overcome these all problem, it is most essential to develop profitable building material from paper sludge. Keeping this in view, investigation was undertaken to produce low-cost concrete by paper sludge.

II. Materials

Portland cement: In our case, we used the Ordinary Portland Cement relevant to IS 12269:2013 of J.k super cement.
Aggregates: The relevant standards we followed during the tests were 383 (1970). Aggregates are the stones retained on the IS sieve of 4.75mm size. For the laboratory experiment, Aggregates of nominal size passing through IS sieve of 20 mm size and retained on IS sieve of 10 mm size.

- **Water:** The water we used here was potable and satisfies all the specifications mentioned in IS 450- (2000) of water quality
- **Admixture:** water content reduced by 15% Adding Admixture **Complast550 by** 1.5% of Weight of cementitious material.

Hypo sludge

Paper sludge is the waste of paper pulp which is generated in the primary sedimentation tank of paper industry. Paper sludge contains low calcium & maximum calcium oxide & high amount of silica. Its composition is almost similar to the cementitious material. It behaves like cement because of silica, calcium & magnesium properties. Its fineness 600 mm that we get from sieve analysis of sludge material. Therefore, we can use paper sludge as a partial replacement of cement content in concrete. Utilization of paper sludge reduces the overall cost of the concrete. Moreover, Silica & magnesium improve the setting of the concrete. In our case, we utilize the paper sludge from J k paper mill, Songadh, Vyara Gujarat.

FIG 1. SEM Image of hypo sludge

TABLE 1 Chemical properties of hypo sludge.

Spectrum processing: No peaks omitted
Processing option: Oxygen by stoichiometry (Normalised)
Number of iterations

Element	Weight%	Atomic %	Compound%	Formula
CaO	24.98	31.55	25.69	CaO
Na K	0.16	0.11	1.39	Na_2O
Mg K	0.24	0.15	2.57	MgO
Al K	0.72	0.41	9.2	Al_2O_3
Si K	0.77	0.42	40.45	SiO_2
S K	0.11	0.05	1.45	SO_3
Cl K	0.13	0.05		
C K	2.97	1.12	0.98	K_2O
Fe K	0.2	0.06	2.69	FeO
O	69.71	66.08		
Totals	100			

FIG 2. Oven dried hypo sludge

FIG 3. Wet hypo sludge

Specific gravity of hypo sludge we get from Pycnometer test by Using oven dry sample.

TABLE 2 Specific gravity of materials

Sr. No.	**Particulars**	**Proportion**
1.	Specific gravity	2.13
2.	cement	3.15
3.	Coarse aggregate	2.9
4.	Fine aggregate	2.45
5.	Admixture	1.145

sr. no.	material	replacement of cementitious material by hypo sludge			
		OPC	20% sludge	30% sludge	30% sludge + 20%

								fly ash	
		b1 W(kg/m^3)	b1 V (m^3)	b2 W (kg/m^3)	b2 V(m^3)	b W(kg/m^3)	b3 V (m3)	b4 W (kg/m^3)	b4 V(m^3)
1	cement	409.2	0.1298	327	0.1038	286	0.0908	204	0.0648
2	water	167.5	0.167	167.5	0.167	167.5	0.167	167.5	0.167
3	hypo sludge			82	0.0385	123	0.0577	123	0.0577
4	fly ash			-	-	-	-	82	0.0372
5	admixture	6.138	0.00537	6.138	0.00537	6.138	0.00537	6.138	0.00537
6	C.A. : 20 mm	682	0.02325	664	0.22914	663	0.22914	654	0.22914
	10 mm	454	0.155	443	0.15276	444	0.15276	436	0.15276
8	F.A.	724	0.2931	706	0.2881	707	0.2281	696	0.2281

TABLE 3 Mix Design Details

III. Procedure:

Concrete mix design procedures were performed according to IS 10262:2019. Mixing, placing, casting & curing procedures were performed according to Indian standard. We cast a standard size cube, beam, and cylinder for testing. Testing procedure for all specimens was performed according to Indian standard. All specimens were tested at Applied Mechanics Department, Faculty of Technology and Engineering, MSU (Vadodara).

FIG 4. Cube

FIG 5. Beam

IV. Observations tables and charts:

TABLE 4 Observation table for workability of concrete

sr. no.	Description	slump value (mm)	compaction factor value
1	OPC	117	0.94
2	OPC + 20% sludge	80	0.86
3	OPC + 30% sludge	76	0.85
4	OPC + 30% sludge + 20% fly ash	85	0.88

TABLE 5 observation table for split tensile strength

sr. no.	Description	split tensile strength (N/mm^2)
1	OPC	3
2	OPC + 20% sludge	2.3
3	OPC + 30% sludge	1.6

TABLE 6 observation table of flexure strength

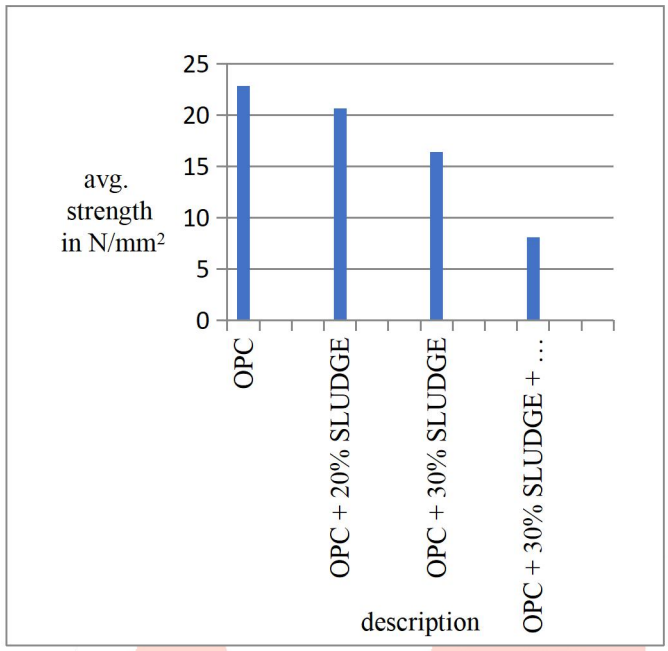
sr. no.	description	flexure strength (bt)	flexure strength (N/mm^2)
1	OPC	2.6	10.06
2	OPC + 20% sludge	3.8	12
3	OPC + 30% sludge	3.7	11.36

Compression test observations and results:

observation table 7 and chart 1 of compressive strength after 7 days of curing:

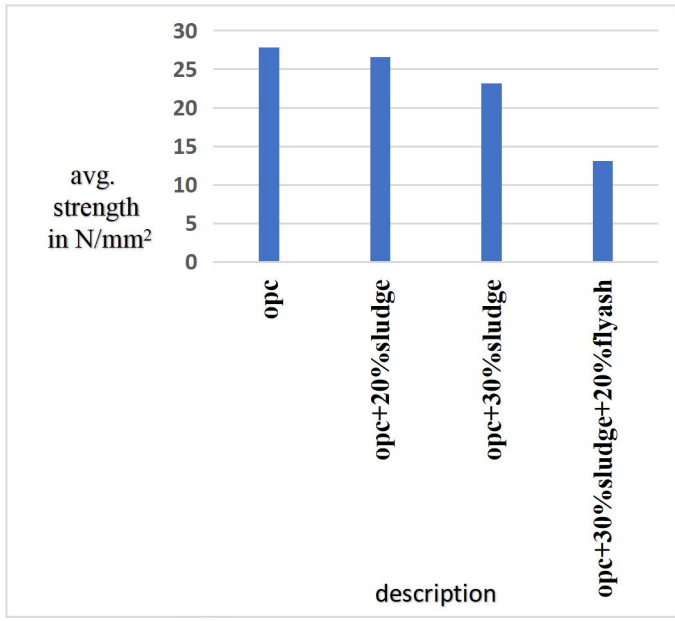
compressive strength of concrete after 7 days of curing		
description	compressive strength in N/mm^2	avg. compressive strength in N/mm^2
OPC	22	22.83
	25	
	21.5	

OPC + 20% sludge	21	20.67
	19.5	
	21.5	
OPC + 30% sludge	16.8	16.43
	15	
	17.5	
OPC + 30% sludge + 20% fly ash	8	8.07
	8.3	
	7.9	



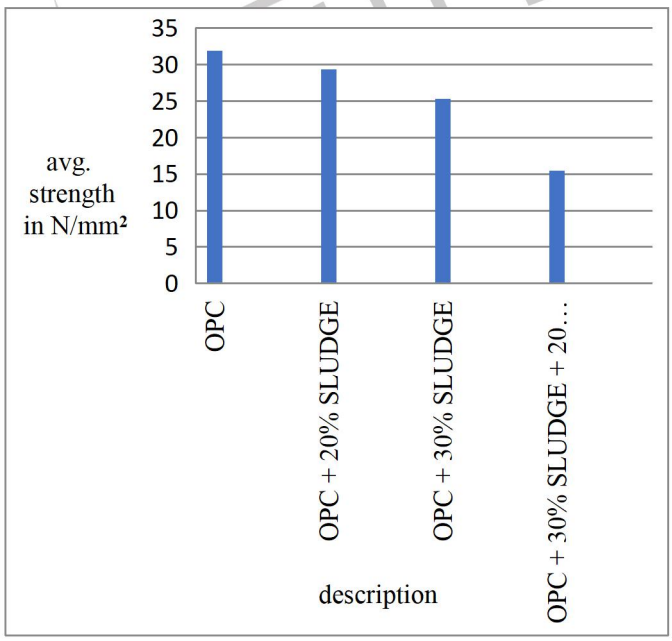
observation table 8 and chart 2 of compressive strength after 14 days of curing:

compressive strength of concrete after 14 days of curing		
description	compressive strength in N/mm^2	avg. compressive strength in N/mm^2
OPC	27.37	27.81
	27.87	
	28.19	
OPC + 20% sludge	26.89	26.55
	25.73	
	27.05	
OPC + 30% sludge	23.31	23.13
	21.19	
	24.89	
OPC + 30% sludge + 20% fly ash	14.4	13.13
	13	
	12	



observation table 9 and chart 3 of compressive strength after 28 days of curing:

compressive strength of concrete after 28 days of curing		
description	compressive strength in N/mm²	avg. compressive strength in N/mm²
OPC	30.42	31.91
	30.97	
	31.33	
OPC + 20% sludge	29.88	29.35
	27.86	
	30.53	
OPC + 30% sludge	25.9	25.3
	23	
	27	
OPC + 30% sludge + 20% fly ash	16	15.48
	16.22	
	14.22	



V. Results

- Workability: as we can see in the table down workability is decreasing as we increased the percentage of paper sludge in concrete.
- Compressive strength: as we can see the table the compressive strength of concrete is a little-bit less than the reference (OPC) cube at 7 days but at 28 days strength of concrete in 20% replacement of OPC cube is equivalent to the reference cube. As we can see that as we increase a sludge in concrete characteristic strength of concrete in decrease. For better results and workability we can say that 20% cement replacement recommendable.
- Flexural strength: flexural strength of concrete increase as we increase the percentage of sludge in concrete but maximum result we get at 20% replacement.
- Split-Tensile strength: It's decrease as we increase a percentage replacement. But slightly decrease at 20% replacement.

VI. Limitation

Calcium contain is less & silica contain is more as compare to cement. Sludge should be fresh and dry. During monsoon sludge may be wet so we need to make it sun dried. Concrete made by hypo sludge should not stand against high temperature. We can't use in furnace or boiler work. Sludge chemical composition change with source so it chemical composition should be check before use. As there are no standard available in India, people are not aware of it and hesitate to adopt it.

VII. Future scope

As we notice in our experiment that the fineness of hypo sludge is a limitation for the replacement of cements. The Fineness of hypo sludge should be improved by a various methods and then we can increase replacement of cement in concrete. To improve quality of hypo sludge calcination can be done at 600'c for 1 hour. Paper sludge concrete can be use in mass concreting because of less heat of hydration. Rapid hardening cement can be use that can be decrease setting time. A New method of hypo sludge & pozzolanic material can be use according to proportion and is standard and study of comparison physical properties of concrete. Increase the use of hypo sludge can be a help to save the environment and made economical structure.

References

[1] Udoeyo F.F., Inyang H., Young D.T., OparaduEd.E., "Potential of Wood Waste Ash as an Additive in Concrete." ASCE, 605-612 (2006).
[2] Mahesh shirur, Yashwanth M. K ,"An experimental study on economical Feasibility and strength of concrete by partial replacement of cement with hypo sludge." (2012).
[3] R.srinivasan, K. Sathiya, and M.palanisamy, Experimental "investigation in developing low-cost concrete from paper industry waste", The Bulletin of the Polytechnic Institute of Jassy, construction. Architecture section (Romania), (2010).
[4] Abullah sand, Manthar Ali keerio, "Feasibillty and strength of concrete by partical replacement of cement with hypo sludge."(2016).
[5] Sajad Ahmad, M Iqbal Malik, Muzaffar Bashir Wani, Rafiq Ahmad, " Study of concrete involving use of waste paper sludge ash as partial replacement of cement."
[6] Dr. Jayeshkumarpitroda, Er. SiddharthTalsania, "Innovative use of paper industry waste(hypo sludge) in pervious concrete"(2016).
[7] Sumit A balwaik, S P Raut, "Utilization of waste paper pulp by partial replacement of cement in concrete."
[8] T. R Naik, "Concrete with paper Industry fibrous Residual, Mixture proportioning", ACI Material Journal, 102(4), July 2005, 237-243.
[9] LodhiRavindrasingh, Akhtar saleem, Bathamgeeta, "Application of paper waste in cement concrete ", (April 2015).
[10] R. Ilakkiya, Dr.G.Dhanalakshmi, "experimental Investigation on concrete using waste paper", (IRJET -2018).
[11] Specifications for Coarse and Fine Aggregates from Natural Sources for Concrete. Bureau of Indian Standards, New Delhi, IS 383 -1970.
[12] IS 10262:2019 "Indian standard for Concrete Mix Proportioning Guidelines for concrete" Bureau of Indian Standards Publications, New Delhi.
[13] IS 516:1959 "Indian standard Methods of Tests for Strength of Concrete" Bureau of Indian Standards Publications, New Delhi
[14] IS 456:2000 "Indian standard code of practice for plain and reinforced concrete" Bureau of Indian Standards Publications, New Delhi.
[15] IS 2386:1963(part I to IX) "Indian standard methods of tests for aggregate for concrete" Bureau of Indian Standards Publications, New-Delhi.
[16] IS 1199:1959 "Indian standard Methods of sampling and analysis of concrete" Bureau of Indian Standards Publications, New Delhi.
[17] IS 9103:1999 "Indian standard specifications for concrete admixtures" Bureau of Indian Standards Publications, New Delhi.
[18] Indian concrete journal (ICJ) special edition m. d. cohen and m. klitsikas "Mechanics of hydration and strength development in Portland cement composites with silica fumes particles"