RESEARCH ARTICLE OPEN ACCESS

An Experimental Investigation of Partial Replacement of Cement by Industrial Waste (Hypo Sludge)

Mr.R.Balamurugan[1], Mr.R.Karthickraja[2]
[1]M.E. Student, Department of Civil Engineering, Jayam Engineering College, Dharmapuri, Tamilnadu, India
[2]M.TECH Student, Department of Civil Engineering, Faculty of Engineering and Technology, PRIST UNIVERSITY, Thanjavur, Tamilnadu, India.

ABSTRACT
Concrete is strength and tough material but it is porous material also which interacts with the surrounding environment. The durability of concrete depends largely on the movement of water and gas enters and moves through it. To produce low cost concrete by blending various ratios of cement with hypo sludge & to reduce disposal and pollution problems due to hypo sludge it is most essential to develop profitable building materials from hypo sludge. To make good quality paper limited number of times recycled Paper fibers can be used which produces a large amount of solid waste. The innovative use of hypo sludge in concrete formulations as a supplementary cementations material was tested as an alternative to traditional concrete. These tests were carried out to evaluate the mechanical properties like compressive strength up to 28 days. As a result, the compressive increased up to 10% addition of hypo sludge and further increased in hypo sludge reduces the strengths gradually. This research work is concerned with experimental investigation on strength of concrete and optimum percentage of the partial replacement by replacing cement via 5%, 10%, 15%, and 20% of Hypo Sludge. Keeping all this view, the aim of investigation is the behavior of concrete while adding of waste with different proportions of Hypo sludge in concrete by using tests like compression strength and split strength.
The mix design was carried out for M25 grade concrete as per IS: 10262-2009.
Keywords—cement; hyposludge; paper waste; OPC

I. INTRODUCTON:

Industrial wastes are being produced per annum by chemical and agricultural process in India. These materials possess problems of disposal, health hazards and aesthetic problem. Paper fibers can be recycled only a limited number of times before they become too short or weak to make high quality paper. It means that the broken, low- quality paper fibers are separated out to become waste sludge. Paper sludge behaves like cement because of silica and magnesium properties which improve the setting of the concrete. The quantity of sludge varies from mill to mill. The amount of sludge generated by a recycled paper mill is greatly dependent on the type of furnish being used and end product being manufactured. Paper mill sludge can be used as an alternative material applied as partial replacement of fine aggregates in manufacturing fresh concrete intended to be used for low cost housing projects. About 300 kg of sludge is produced for each tone of recycled paper. This is a relatively large volume of sludge produced each day that makes making landfill uneconomical as paper mill sludge is bulky. By adjusting the mixture to an equivalent density, concrete mixtures containing the residuals can be produced that are equal in slump and strength to a reference concrete without residuals.

II. LITERATURE REVIEW

Experimental investigations in developing low cost concrete from paper industry waste R. Srinivasan, *K. Sathiya and M. Palanisamy, 2010

Over 300 million tones of industrial wastes are being produced per annum by chemical and agricultural process in India. These materials pose problems of disposal and health hazards. The wastes like phosphogypsum, fluorogypsum and red mud contain obnoxious impurities which adversely affect the strength and other properties of building materials based on them

Utilization of waste paper pulp by partial replacement of cement in concrete Sumit A Balwaik; S P Raut, ISSN: 2248-9622

The use of paper-mill pulp in concrete formulations was investigated as an alternative to landfill disposal. The cement has been replaced by waste paper sludge accordingly in the range of 5% to 20% by weight for M-20 and M-30 mix. By using adequate amount of the waste paper pulp and water, concrete mixtures were produced and compared in terms of slump and strength with the conventional concrete.

III. MATERIAL COLLECTION AND CHARACTERISATION

SUPPLEMENTARY CEMENTITIOUS MATERIAL:

1) HYPO SLUDGE,
2) CEMENT
3) COARSE AGGREGATE
4) FINE AGGREGATE
5) WATER

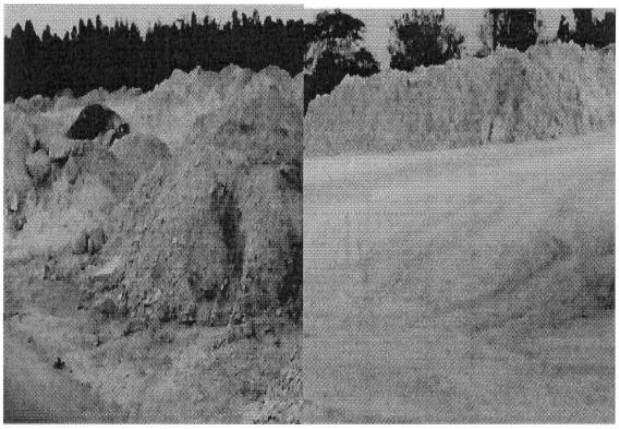
IV. PROPERTIES OF MATERIALS

Waste Paper Sludge Ash (WPSA) is a waste material collected from the Paper Industry. WPSA is used as cement replacement in producing mortar and was investigated on its chemical, physical and mechanical properties. Construction material with natural resources now become limited and causes of air pollution and environmental problems. WPSA becomes a new innovation material that can be used as material for masonry to support the green technology due to less presence of sulphate at only 0.57% of the total weight. Carbon dioxide (CO_2) and Sulphur dioxide emission also can be reduced since less cement productivity is involved. The chemical and physical properties of the WPSA were determined by comparing it with the Ordinary Portland Cement (OPC).

As the result of testing, it shows that WPSA is similar to the chemical properties of OPC and the water absorption of the mortar is 27.05%. However the total percentage of the three combinations of SiO_2, Al_2O_3 and Fe_2O_3 was 45% and expected to possess low pozzolanic reactivity (50%). WPSA was used in mortar with proportions of 50%, 60%, 70%, 80%, 90% and 100% as cement replacement by volume along with sand and water in fix quantity. An additional control mix mortar without WPSA was also prepared. The compressive strength of each mortar mix was also determined on 3, 7, 28 and 60 days. Results show that the compressive strength increased with increasing curing age for all concrete mixes and the compressive strength decreases with increasing WPSA in the mortar. The inclusion of 50% WPSA can gain favorable strength mortar at 16.4 MPa. Meanwhile 70% and 100% replacement can be adopted for economical environmental mortar to suit lower strength mortar construction at 12.5 MPa and 7.7 MPa respectively.

HYPO SLUDGE

Where, this hypo sludge contains, low calcium and maximum calcium chloride and minimum amount of silica. Hypo sludge behaves like cement because of silica and magnesium properties. This silica and magnesium improve the setting of the concrete As the result of testing, it shows that WPSA is similar to the chemical properties of OPC and the water absorption of the mortar is 27.05%. However



the total percentage of the three combinations of SiO_2, Al_2O_3 and Fe_2O_3 was 45% and expected to possess low pozzolanic reactivity (50%). WPSA was used in mortar with proportions of 50%, 60%, 70%, 80%, 90% and 100% as cement replacement by volume along with sand and water in fix quantity. An additional control mix mortar without WPSA was also prepared. The compressive strength of each mortar mix was also determined on 3, 7, 28 and 60 days. Results show that the compressive strength increased with increasing curing age for all concrete mixes and the compressive strength decreases with increasing WPSA in the mortar. The inclusion of 50% WPSA can gain favorable strength mortar at 16.4 MPa. Meanwhile 70% and 100% replacement can be adopted for economical environmental mortar to suit lower strength mortar construction at 12.5 MPa and 7.7 MPa respectively.

TABLE-1 PROPERTIES OF RAW HYPO SLUDGE

SL.NO	CONSTITUENT	PRESENT IN HYPO SLUDGE (%)
1.	MOISTURE	56.8
2.	MAGNESIUM OXIDE(MGO)	3.3
3.	CALCIUM OXIDE (CAO)	46.2
4.	LOSS ON IGNESCENT	27.00
5.	ACID INSOLUBLE	11.1
6.	SILICA(SiO_2)	9.0
7.	R_2O_3	3.6

TABLE-2 PROPERTIES OF HYPO SLUDGE AS CEMENT INGREDIENT

SL.NO	CONSTITUENT	PRESENT IN HYPO SLUDGE (%)
1.	MAGNESIUM OXIDE(MGO)	3.3
2.	CALCIUM OXIDE (CAO)	46.2
3.	LOSS ON IGNESCENT	27.00
4.	ACID INSOLUBLE	11.1
5.	SILICA(SiO_2)	9.0
6.	R_2O_3	3.6

TABLE-3 COMPARISON OF CEMENT AND HYPO SLUDGE

SL.NO	CONSTITUENT	CEMENT (%)	HYPO SLUDGE (%)
1.	LIME(CAO)	62	46.2
2.	SILICA(SiO_2)	22	9
3.	ALUMINA	5	3.6
4.	MAGNESIUM	1	3.33
5.	CALCIUM SULPHATE	4	4.05

SCOPE

A) TO PROVIDE A MOST ECONOMICAL CONCRETE.
B) IT SHOULD BE EASILY ADOPTED IN FIELD.
C) USING THE WASTES IN USEFUL MANNER.
D) TO REDUCE THE COST OF THE CONSTRUCTION.
E) TO PROMOTE THE LOW COST HOUSING TO THE E.W.S. GROUP PEOPLE.
F) TO FIND THE OPTIMUM STRENGTH OF THE PARTIAL REPLACEMENT OF CONCRETE.
G) MINIMIZE THE MAXIMUM DEMAND FOR CEMENT.
H) MINIMIZE THE MAXIMUM DEGRADATION IN ENVIRONMENT DUE TO CEMENT AND SAFEGUARD THE OZONE LAYER FROM GREEN HOUSE GASES.
I) TO STUDY THE CRACK DEVELOPMENT IN HARDENED CONCRETE.

Cement: (OPC)

The most common cement used is an ordinary Portland cement. The Ordinary Portland Cement of 53 grades conforming to IS: 8112-1989 is being used. Cement (PPC) The most common cement used is Portland pozzolana cement. The Portland pozzolana cement of 53 grades conforming to IS: 1489 (PART-1) 1991 is being used

Table-4 PROPERTIES OF 53 GRADE CEMENT

SL NO	PHYSICAL PROPERTIES OF GRADE CEMENT	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/mm2 at 28 days	58 N/mm2	53 N/mm2 minimum

TABLE-5 CHEMICAL PROPERTIES OF OPC CEMENT

SL.NO	CONSTITUENTS	CHEMICAL PROPERTIES OF OPC 53 GRADE CEMENT
1.	SiO_2	28.7
2.	CaO	53.6
3.	Al_2O_3	13.5
4.	MgO	2.21
5.	Fe_2O_3	2.27
6.	Loss on ignition	2.05
7.	Chloride	0.07

Aggregate:

Aggregates are the important constituents in concrete. They give body to the concrete, reduce shrinkage and effect economy. One of the most important factors for producing workable concrete is a good gradation of aggregates. Good grading implies that a sample fraction of aggregates in required proportion such that the sample contains minimum voids. Samples of the well graded aggregate containing minimum voids require minimum paste to fill up the voids in the aggregates. Minimum paste means less quantity of cement and less water, which are further mean increased economy, higher strength, lower shrinkage and greater durability.

Coarse Aggregate:

The fractions from 20 mm to 4.75 mm are used as coarse aggregate. The Coarse Aggregates from crushed Basalt rock, conforming to IS: 383 are

being used. The Flakiness and Elongation Index were maintained well below 15%. Physical property evaluation and gradation of coarse aggregate were carried out and the test results are presented below:

TABLE-6 PHYSICAL PROPERTIES COURSE AGGREGATE:

Sl.No	PHYSICAL PROPERTIES	RESULT
1.	Specific gravity	2.6
2.	Fineness modulus	2.98
3.	Water absorption	0.50%
4.	Free moisture content	0.10%
5.	Aggregate impact value	12
6.	Aggregate crushing value	23

Fine aggregate:

Those fractions from 4.75 mm to 150 micron are termed as fine aggregate. The river sand and crushed sand is being used in combination 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. Sieve analysis and physical property evaluation of fine aggregate were carried out and the test results are presented below:

TABLE-7 PHYSICAL PROPERTIES OF FINE AGGREGATE:

SL.NO	**PHYSICAL PROPERTIES**	**TEST RESULT**
1.	Specific gravity	2.65
2.	Fineness modulus	2.8
3.	Water absorption	0.65%
4.	Free moisture content	0.20%

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.

TABLE-8 PHYSICAL PROPERTIES OF WATER:

S.NO	**PARAMETER**	**RESULT**	**LIMITS IS : 456(12)**
1	PH	6.92	6.5 -8.5
2	Chloride	52 mg/l	2000mg/l(pcc) 500mg/l(rcc)
3	Alkalinity	7ml	<25ml
4	Sulphate	128 mg/l	400mg/l
5	Fluorides	0.04 mg/l	1.5 mg/l
6	Organic solids	56 mg/l	200mg/l
7	Inorganic solids	129 mg/l	3000mg/l

DESIGN MIX:

A mix M25 grade was designed as per Indian Standard method (IS 10262-1982) and the same was used to prepare the test samples.

MIX PROPORTIONS FOR TRIAL NUMBER 1

Cement = 281.60 kg/m^3
Hypo sludge = 70.4 kg/m^3
Binding material = 352kg/m^3(1)
Water =140 kg/m3
Fine aggregate = 485.8 kg/m^3 (1.3)
Coarse aggregate = 781.3 kg/m^3 (2.2)
Water-cement ratio = 0.42

V. CASTING OF CONVENTIONAL CONCRETE AND HYPOSLUDGE CONCRETE

Casting of conventional concrete of M25 mix ratio and also casting of 5%,10%,15% and 20% replacement of cement by hyposludge Following are the pictures taken during casting of concrete.

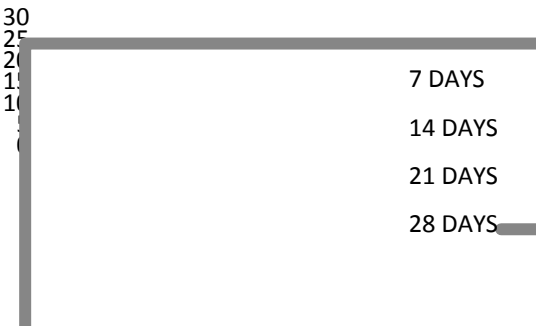
We casted convention concrete with M25 mix design, we casted 20 cubes of around for conventional concrete of cube size 150 mm x 150mm x 150 mm. and 100 mm x 100mm x 100mm.

VI. COMPARISON OF RESULTS

M25 MIX / **NO OF DAYS**	**CONVENTIONAL CONCRETE N/mm2**	**5% HYPO SLUDGE CONCRETE N/mm2**	**10% HYPO SLUDGE CONCRETE N/mm2**	**15% HYPO SLUDGE CONCRETE N/mm2**	**20% HYPO SLUDGE CONCRETE N/mm2**
7 DAYS	**14.22**	**11.55**	**13.11**	**10.66**	**10.44**
14 DAYS	**17.56**	**17.11**	**17.55**	**14.22**	**12.88**
21 DAYS	**23.33**	**22.00**	**24.44**	**18.88**	**17.11**
28 DAYS	**24.88**	**24.22**	**24.66**	**22.00**	**21.11**

SLUMP VALUE:

M25 concrete mix (conventional concrete) =96mm
5% hypo sludge concrete = 98 mm
10% hypo sludge concrete = 95 mm
15% hypo sludge concrete = 94 mm
20% hypo sludge concrete = 92 mm



VII. COMPARISON OF COMPRESSIVE STRENGTH RESULTS WITH AND WITHOUT SILICA ADMIXTURES

NO OF DAYS	15% HYPO SLUDGE CONCREE WITHOUT ADMIXTURE N/mm2	15% HYPO SLUDGE CONCREE WITH SILICA ADMIXTURE N/mm2
7	10.66	12.22
14	14.22	15.55
21	18.88	20.66
28	22.00	23.33

VIII. CONCLUSION:

Finally I conclude our project with full satisfaction of completing the project Casting of conventional cement concrete cubes has been done Casting of concrete cube added with industrial waste(fly ash) has also been done Comparison of results has been done Testing of concrete cubes with various methods like compression and slump test has been done for both cubes Upto 10% of hyposludge concrete, the compression strength has been increased,soupto 10% cement has been replaced by hyposludge By replacement of hyposludge the cost of construction should be minimized By effective utilization of waste product into concrete to also reduce the environmental effects.If silca is added means the strength will be considerably increased because of lack of silica in hypo sludge Considerably this Type Of Concrete Will Be Used For Road Works Effectively With Less Consumption Of Cement.

REFERENCES

[1] Hypo Sludge Management: Opportunities For Developing Low Cost Concrete With Glass Fibers, Volume : 1 | Issue : 7 | Dec 2012 • ISSN No 2277 – 8160 **Jayeshkumar Pitroda, Dr. L. B. Zala, Dr F. S. Umrigar**

[2] Experimental Investigation In Developing Low Cost Concrete From Paper Industry Waste **R. Srinivasan, *K. Sathiya And M. Palanisamy,2010**

[3] An Exploration Study On Stone Waste As Foregoing Alternatives For Green Concrete **Ankit Nileshchandra Patel 1, Prof. Jayeshkumar Pitroda 2, IJAERS/Vol. II/ Issue III/April-June, 2013/35-38**

[4] Utilization Of Waste Paper Pulp By Partial Replacement Of Cement In Concrete**Sumit A Balwaik*; S P Raut** Vol. 1, Issue 2, pp.300-309**

[5] Durability Of Concrete With Partial Replacement Of Cement By Paper Industry Waste (Hypo Sludge) **Jayeshkumar Pitroda, L.B.Zala, F S Umrigar, ISSN: 2278-3075, Volume-2, Issue-3, February 2013.**

[6] Recycling Of Waste Paper Sludge In Cements Characterization And Behavior Of New Eco-Efficient Matrices **Moisés Frías1, Iñigo Vegas2,Raquel Vigil De La Villa3 And Rosario García Giménez3,**

[7] Investigation Of Low Cost Concrete Using Industrial Waste As Supplementary Cementitious Materials **Jayrajvinodsinhsolanki1, Jayeshkumar Pitroda 2 1student Of Final Year M.E. C E & M, B.V.M. Engineering College, Vallabh Vidyanagar, Aug 2011**

[8] Evaluation Of Modulus Of Elasticity Of Concrete With Partial Replacement Of Cement By Thermal Industry Waste (Fly Ash) And Paper Industry Waste (Hypo Sludge) **Jayeshkumar R. Pitroda, Dr F S Umrigar2 1 Assistant Professor & Research Scholar, Civil Engg Department, B.V.M. Engg. College, Vallabh Vidhyanagar Volume 2, Issue 1, January 2013**

[9] Stone Waste As A Groundbreaking Conception For The Low Cost Concrete**Ankit Nileshchandra Patel 1, Prof. Jayeshkumar Pitroda Student Of Final Year M.E. C E & M, B.V.M. Engineering College, Vallabhvidyanagar, Volume4Issue4- April 2013**

[10] Effect Of Hypo Sludge As Partial Replacement With Cement In Mortar **Rushabh A. Shah* Prof. Jayeshkumar Pitroda**, (APRIL 2013)**