A STUDY ON LOW COST RIGID PAVEMENT USING HYPO SLUDGE WASTE FROM PAPER INDUSTRY

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ABSTRACT

The paper producing industry generates various wastes coming out from the various processes. Major initiatives are needed in India to use these large volumes in construction industry especially in rigid pavement constructions. Moreover, use of Hypo Sludge in construction of pavement will improve transportation functionality. Our study is concerned with eco coefficient utilization of Hypo Sludge as partial replacement of cement in concrete for development of low-cost rigid pavement of road infrastructure.

Hypo Sludge concrete are made a 'greener' building material and the discarded natural wastes can be re-utilized, avoiding otherwise wasteful landfill and harmful open incineration. To make value added concrete for development of sustainable infrastructure there is a great need to study the technical details concerned with various industrial wastes in concrete and to reduce environmental hazards.

Keyword: *- Hypo Sludge, Utilization of Waste, Low cost Construction.*

1. General

To save energy and to earn carbon credit is very much essential for the betterment of mankind. To produce Ordinary Portland Cement, we use earth resources like limestone etc & during manufacturing of 1 ton of Ordinary Portland Cement an equal amount of carbon dioxide is released into the atmosphere which is harmful to the environment.

Paper mill sludge is a major environmental problem for the paper and board industry. The material is by-product of the de-inking and re-pulping of paper. The million tons quantity of paper mill sludge produced in the world. Paper sludge behaves like cement because of silica and magnesium properties which improve the setting of the concrete. 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 to be used for low cost projects.

1.1 Hypo-sludge

Hypo-sludge is one of the by-products from the paper industry .The use of these byproducts offers environmental advantages, diverts the material from the waste stream, reduces the energy used in processing virgin materials and decreases pollution. India is a resourceful country for generation of the industrial wastes with an annual output of over 300 million tones. But utilization is still below 20 % in spite of quantum jump in last three to four years.

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 relatively a large volume of sludge produced each day that makes land filling uneconomical as paper mill sludge is bulky.

1.2 Need for hypo-sludge utilization

- While producing paper the various wastes come out from the various processes in paper industries. From the preliminary waste hypo-sludge, due to its low calcium, is taken out for our project to replace the cement in concrete.
- Due to the cement production greenhouse gases are emitted in the atmosphere. For producing 4 million tons of cement 1 million ton of greenhouse gases are emitted. Also, to reduce the environmental degradation this sludge has been avoided in mass level disposal in land.
- To eliminate the ozone layer depletion, production of cement needs to be reduced. For this, the hypo sludge is used as partial replacement in the concrete as high-performance concrete. By utilizing this waste, the strength will be increased and also cost reduction in the concrete is achieved.

1.3 Problem statement:

1. Few industries among all discards the waste which are contaminating the environment and its surrounding. This harms every creature living in that locality.
2. Consumption of cement in the construction industry resulting indirectly the emission of carbon dioxide in the manufacturing process of cement.
3. The use of lime sludge can be explored for structural and non-structural applications by conducting future experimental studies.

1.4 Objectives:

1. To study and compare compressive strength of normal concrete mix and addition of Hypo Sludge in concrete mix.
2. To achieve the optimum strength of the partial replacement of cement (By Laboratory Tests)
3. To investigate the utilization of Hypo Sludge as supplementary cementitious Material (SCM).
4. To establish sustainable connectivity and promote good health and well-being.

2. METHODOLOGY

In this present experimental study cement, aggregates, water, hypo-sludge and super plasticizer is used to prepare the cubes and cylinders to test the workability, compressive and tensile strength of concrete. A total of 60 numbers of concrete specimens were casted. Three cube moulds of standard size 150 x 150 x 150mm were casted for 7 days strength and other three cube moulds of same size casted for 28 days strength for different proportions of SCBA. In a similar manner three cylinders of 150mm diameter and 300mm length were casted for 7 days tensile strength and other three cylinders of same size casted for 28 days strength. The mix design of concrete is done according to Indian Standard guidelines by using IS code 10262:2009 for M30 grade of concrete. In this present work the cement is replaced by SCBA in 0%, 10%, 20%, 30% and 40% by weight and also the study is done with super plasticizer and without super plasticizer.

2.1 Hypo-sludge

The 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. The raw dry paper sludge mainly contains silica and calcium oxide, followed by alumina and magnesium oxide.

Table -1 Properties of raw hypo-sludge

SL NO	Constituents	Present in Hypo Sludge (%)
01	Moisture	56.83
02	Magnesium oxide (Mgo)	3.3
03	Calcium Oxide (CaO)	46.2
04	Loss on ignescent	27
05	Acid Insoluble	11.1
06	Silica (SiO_2)	9.0
07	$R_2 O_3$	3.6

Table -2 Properties of hypo-sludge as cement ingredient

SL NO	Constituents	Present in Hypo Sludge (%)
01	Magnesium oxide (Mgo)	3.3
02	Calcium Oxide (CaO)	46.2
03	Loss on ignescent	27
04	Acid Insoluble	11.1
05	Silica (SiO_2)	9.0

2.2 Tests on fresh concrete and hardened concrete

Tests on fresh concrete

Workability Test: The term workability is used to describe the ease or difficulty with which then Concrete is handled, transported and placed between the forms with minimum loss of homogeneity. The following tests are commonly employed to measure workability.

1. Slump cone Test
2. Compaction factor test
3. Vee – bee consistometer test

Tests on hardened concrete

1. Compressive Strength Test

For evaluating the compressive strength, specimens of dimensions 150 x 150 x 150mm were casted. They were tested on 2000 KN capacity compression testing machine as per IS: 516 - 1959.

2. Split Tensile Strength Test

For evaluating the tensile strength, cylindrical specimens of diameter 150 mm and length 300 mm were casted. Split tensile strength test was carried out on 2000 kN capacity compression testing machine as per IS: 5816 - 1999.

3. RESULT AND DISCUSSION

The mix design and quantities calculation to be carried out and discussing the test results of hypo sludge concrete with the conventional concrete. The economic feasibility to be compared.

Table -2 Compressive strength of cubes at 7 days

Partial replacement %	**Number of specimens**	**Area of specimen (mm^2)**	**Average compressive strength N/mm^2**
0%	3	22500	16.07
10%	3	22500	10.66
20%	3	22500	12.27
30%	3	22500	14.2
40%	3	22500	12.23

Chart -1 Compressive strength of cubes at 7 days

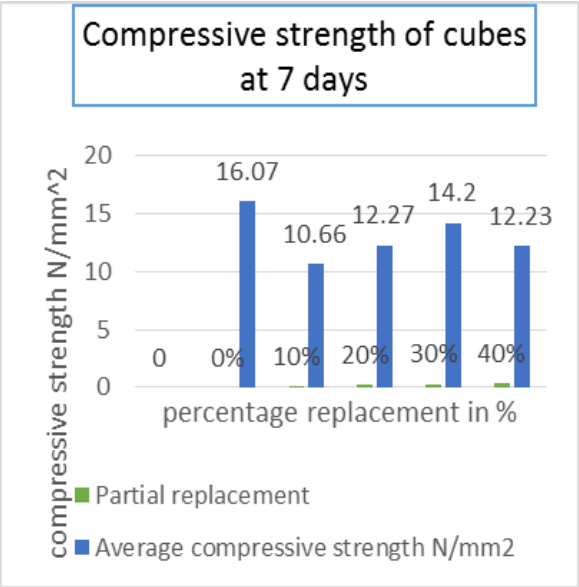


Table -3 Compressive strength of cubes at 28 days

Partial replacement %	**Number of specimens**	**Area of specimen (mm^2)**	**Average compressive strength N/mm^2**
0%	3	22500	33.86
10%	3	22500	32.73
20%	3	22500	33.43
30%	3	22500	31
40%	3	22500	28.23

Chart -2 Compressive strength of cubes at 28 days

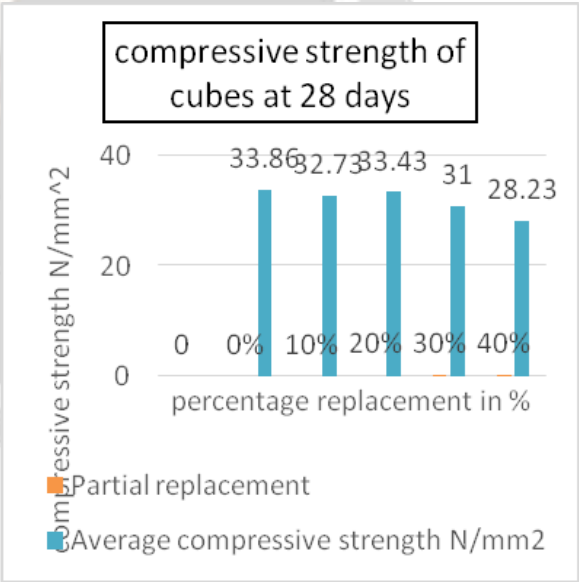


Table -4 Split Tensile Strength for 7 days

Partial replacement %	**Number of specimens**	**Area of specimen ($mm^{2)}$**	**Average Split Tensile strength N/mm^2**
0%	3	17671.45	1.45
10%	3	17671.45	1.51
20%	3	17671.45	1.53
30%	3	17671.45	1.7
40%	3	17671.45	1.3

Chart -3 Split Tensile Strength for 7 days

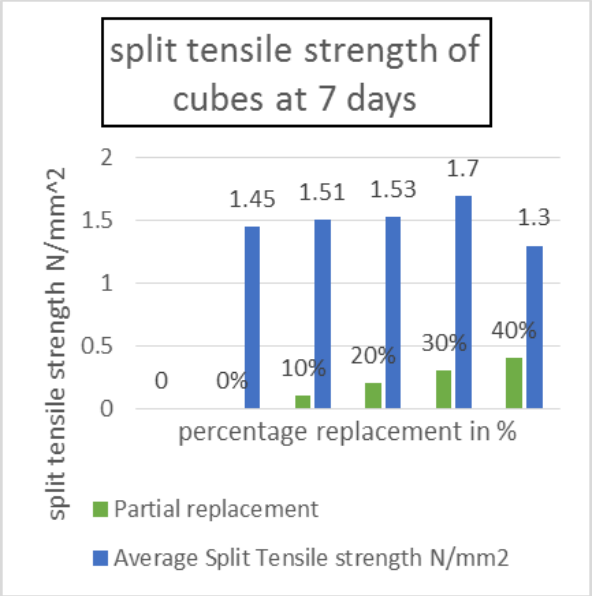
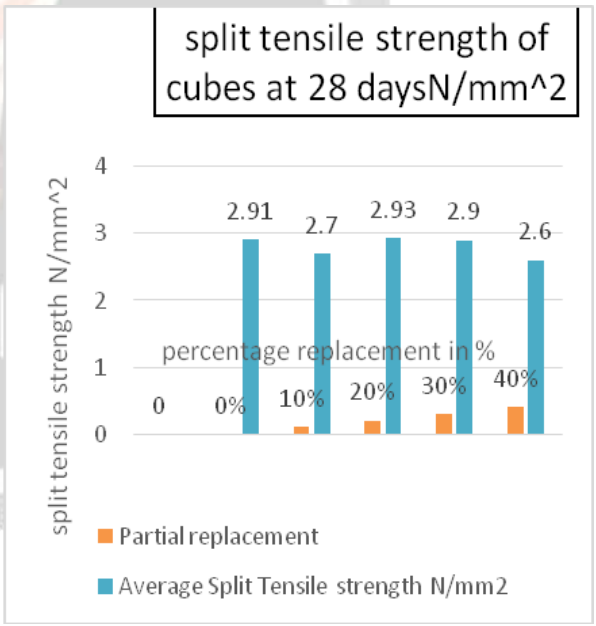


Table -5 Split Tensile Strength for 28 days

Partial replacement %	**Number of specimens**	**Area of specimen ($mm^{2)}$**	**Average Split Tensile strength N/mm^2**
0%	3	17671.45	2.91
10%	3	17671.45	2.7
20%	3	17671.45	2.93
30%	3	17671.45	2.9
40%	3	17671.45	2.6

Chart -4 Split Tensile Strength for 28 days



3.1 Economic Feasibility

Table -6 Cost of material of 0% sludge in concrete mix

Description	Quantity(kg/m^3)	Cost(Rs)	Cost of Material (Rs)
Cement	394	7/kg	2758
Hypo Sludge	-	2/kg	-
Fine aggregate	0.406 Brass	3200/ Brass	1299.2
Coarse aggregate	0.61 Brass	2600/ Brass	1586
		Total cost	5643.2

Table -7 Cost of material of 10% sludge in concrete mix

Description	Quantity(kg/m^3)	Cost(Rs)	Cost of Material (Rs)
Cement	354.6	7/kg	2482.2
Hypo Sludge	39.4	2/kg	78.8
Fine aggregate	0.406 Brass	3200/ Brass	1299.2
Coarse aggregate	0.61 Brass	2600/ Brass	1586
		Total cost	5446.2

Table -8 Cost of material of 20% sludge in concrete mix

Description	Quantity(kg/m^3)	Cost(Rs)	Cost of Material (Rs)
Cement	354.6	7/kg	2482.2
Hypo Sludge	39.4	2/kg	78.8
Fine aggregate	0.406 Brass	3200/ Brass	1299.2
Coarse aggregate	0.61 Brass	2600/ Brass	1586
		Total cost	5446.2

Table -9 Cost of material of 30% sludge in concrete mix

Description	Quantity(kg/m^3)	Cost(Rs)	Cost of Material (Rs)
Cement	275.8	7/kg	1930.6
Hypo Sludge	118.2	2/kg	236.4
Fine aggregate	0.406 Brass	3200/ Brass	1299.2
Coarse aggregate	0.61 Brass	2600/ Brass	1586
		Total cost	5052.2

Table -10 Cost of material of 40% sludge in concrete mix

Description	Quantity(kg/m^3)	Cost(Rs)	Cost of Material (Rs)
Cement	236.4	7/kg	1654.8
Hypo Sludge	157.6	2/kg	315.2
Fine aggregate	0.406 Brass	3200/ Brass	1299.2
Coarse aggregate	0.61 Brass	2600/ Brass	1586
		Total cost	4855.2

Closure

The compressive and tensile strength for the mix with superplasticizer replaced with 30% of cement by hypo-sludge gives better values and is nearer to that of normal concrete tested results

4. CONCLUSIONS

1) Compressive strength of the concrete can be increased when the percentage of replacement is increased up to 30% and when the replacement is increased above 30% compressive strength decreases.
2) The split tensile strength of concrete has decreased when the percentage of the replacement with hypo sludge is increased.
3) Use of hypo sludge in concrete can save the paper industry disposal costs and produces a greener concrete for construction.
4) Disposal problem of the hypo sludge can be minimized by this project as now a days it is a big problem.
5) Environmental effects from wastes and residuals of cement manufacturing can be reduced through this low-cost concrete.
6) From this level, replacement of cement with this waste of hypo sludge material provides maximum compressive strength at 30% replacement.

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