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Sustainable Development and Eco Friendly Construction of Low Cost Rural Roads by using Hypo Sludge

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Abstract **–The aim of the present study is to investigate the low cost rural roads made of Hypo sludge. From the preliminary waste named as hypo sludge ,due to its low calcium is taken out to replace the cement in concrete. Rural structure is the key to inclusive growth by connecting the rural hinterlands and enabling the roll out of many additional socio-economic sciences. With a growing rural road network of the country and with ambitious rural road development plans, there is a great need for the roads sector to build a sustainable environment- friendly road infrastructure for low volume rural roads. It is also needed to reduce the cost of concrete for rural development in India. A cement concrete pavement is designed for a Rural Road in Coimbatore district having a traffic volume of up to 500 vehicles per day. The soil has a soaked CBR value of 4% and design wheel load 30kN. So this study is concerned with eco- friendly utilization of hypo sludge as partial replacement of cement in concrete. The hypo sludge was replaced within the range of 10-30% by weight of cement. Moreover use of hypo sludge in construction of rigid pavement will improve transportation functionality and ecological sustainability and results in improved traffic safety and reduced life cycle cost.**

Keywords: Hypo sludge, eco friendly, rigid pavement, CBR, Rural roads, Cost.

I. INTRODUCTION

Hypo sludge in construction of rigid pavement will benefit urban growth, public health and surrounding communities by encouraging smart growth by integrating and guiding future growth. It is also needed to reduce the cost of concrete pavement of rural road development in India. So our study is concerned with eco-friendly utilization of hypo sludge as partial replacement of cement in concrete for the development of low cost rigid pavement of rural road infrastructure. Transportation has serious impacts on the lives and welfare of the rural people. 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. In recent years, they need to achieve sustainable strategies has become of greater concern, also become some traditional disposal options, such as landfill, are progressively restricted, and in some cases banned, by legislation. In industrial currently in India about 980 million tons of solid waste is being generated annually as by product of which around 390 million tons are organic, around 300 million tons inorganic from industrial sector are hazardous in nature. Paper making generally produces a large amount of solid waste. Paper fibres can be recycled only a limited number of times before they become too short or too weak to make high quality paper. It means that the broken, low quality paper fibres are separated out to become waste sludge. To reduce the disposal problems, these paper waste is used in the development of rural roads.

II. LITERATURE REVIEW

Abdullah Shahbaz Khan et al, this paper presented the hypo sludge behaves like cement because of silica and magnesium properties. The behaviour of these two components increases the setting time of concrete . dissertation work is carried out with M30 grade concrete with water cement ratio 0.45. Tests was conducted to study the mechanical properties of concrete such as compressive strength of concrete, spilt tensile strength and flexural strength of concrete.

Jayeshkumar Pitroda, this paper deals with the hypo sludge for the rigid pavement, it was observed with the CBR value of 2%,4%,6% and the wheel load is taken as 30kN with the thickness of 150mm and the cost of slab also analysed in this research. The cost of slab decreases for different percentages and for the different thickness is adopted.

III. MATERIALS AND ITS PROPERTIES

A. Hypo sludge

The production of hypo sludge is estimated about 35% of the daily production in paper industries. These wastes are used as an ingredient of cement manufacturing in wet process as well as in dry process. The paper industries are damped these wastes nearby any pit or waste land. It also leads to effects in pollution.

Table 1:Physical properties of Raw Hypo sludge

S.no	Property	Result
1.	Specific gravity	1.46

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Table 2:Initial setting time and Final setting time

S.no	Ingredients	Initial setting (min)	Final setting (min)
1.	Cement +10% hypo sludge	31	598
2.	Cement +15% hypo sludge	32	597
3.	Cement +20% hypo sludge	33	597
4.	Cement +25% hypo sludge	33	596
5.	Cement +30% hypo sludge	34	595

Table 3:Chemical properties of hypo sludge

S.no	**Constituent**	**Present in hypo sludge (%)**
1.	Moisture	56.8
2.	Magnesium oxide (MgO)	4.7
3.	Calcium oxide (CaO)	46.1
4.	Loss on ignescent	27
5.	Acid insoluble	13.8
6.	Silica(Sio_2)	4.0
7.	R_2O_3	3.6

Properties of Hypo Sludge

- It improves the properties of fresh and harden concrete.
- It improves the durability of concrete.
- It is the cheaper substitute to OPC.
- It reduces degradation and bleeding.

B. Cement

The cement was generally classified on the basis of three grades viz,33 grade,43 grade and 53 grade depending upon the strength of the cement at 28 days when tested as per Indian standards. Cement acts as a binding material used in the preparation of concrete. it binds the coarse aggregate and fine aggregate with the help of water and it also fills the voids in the concrete.

Table 4:properties of cement

S.no	**Property of 53 grade cement**	**Result**
1.	Specific gravity	3.15
2.	Consistency	33%
3.	Initial setting time	30 min
4.	Final setting time	600 min

C. FINE AGGREGATE

It should be properly graded to give minimum void ratio and be free from deleterious materials like clay, silt content and chloride contamination etc. The properties of fine aggregate was analysed as per IS383-1970. The physical properties of fine aggregate like specific gravity, fineness modulus and water absorption are tested in accordance with IS:2386.

Table 5:properties of fine aggregate

S.no	**Property**	**Result**
1.	specific gravity	2.6
2.	Fineness modulus	4.67%
3.	Water absorption	1.0%
4.	Gradation	Zone I

D. COARSE AGGREGATE

Aggregate it consists of naturally occurring stones(crushed, broken or unbroken). It should be hard, strong, dense, durable and clean. It should be roughly cubical in shape. Flaky pieces should be avoided. Water absorption of aggregate should not more than 10% of its weight after 24 hours immersion in water. The physical properties of coarse aggregate like specific gravity, fineness modulus and water absorption are tested in accordance with IS:2386.

Table 6:properties of coarse aggregate

S.no	**Property**	**Result**
1.	specific gravity	2.8
2.	Fineness modulus	13.7%
3.	Water absorption	0.5%

E. WATER

It is the important ingredient which it chemically participates in the reaction with cement to form the hydration product, C-S-H gel. The strength of cement mortar depends mainly from the binding action of the hydrated cement paste gel.

IV. MIX PROPORTIONS

By using mix design IS10262:2009 it was designed for the Portland pozzolana cement having compressive strength 28 days strength of M30.

Table 7: Design methodology

Hypo sludge %	w/c ratio	Cement(kg/m^3)	F.A (kg/m^3)	C.A(kg/m^3)	Water (kg/m^3)	Hypo sludge(kg/m^3)
0	0.45	425	684	1152	191	-
10	0.45	382	667	1123	191	42.5
15	0.45	361	660	1112	191	63.75
20	0.45	340	650	1096	191	85
25	0.45	318	643	1084	191	106
30	0.45	297	634	1068	191	128

V. EXPERIMENTAL RESULTS

A.Compressive Strength Of Concrete

The compressive strength of concrete is one of the most important and useful properties of concrete. It is generally determined by testing cubes of size 150 x 150 x 150 mm that was done in the lab. In this test, the cubes are subjected to compressive force in a compression testing machine and the ultimate load at which the failure occurs is noted. Then the compressive stress is ultimate load by area exposed to load and stress value is obtained in N/mm^2. It is calculated by (P/A).

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Fig 1-Testing of compressive strength of concrete

Fig 2:Setup of flexural strength of concrete

Table 8-Compressive strength of concrete

Type of specimen	7 days(N/mm^2)	28 days (N/mm^2)
Conventional	23.3	35.5
10% replacement	24	36.9
15%	25.6	38.5
20%	20.3	30.7
25%	19.2	28.6
30%	18.5	27.8

Table 9-Flexural strength

Type of specimen	28 days (N/mm^2)	90 days(N/mm^2)
Conventional	4.83	5.36
10%	4.59	4.62
15%	4.32	4.48
20%	3.84	4.02
25%	3.42	3.65
30%	2.85	2.98

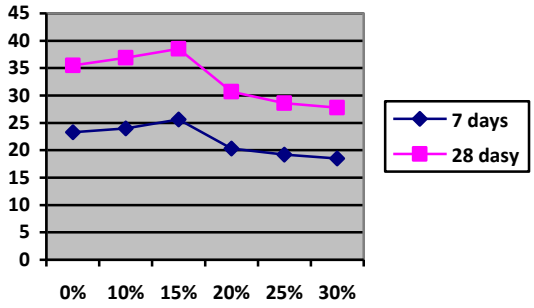

Chart1- Compressive strength at 7 and 28 days

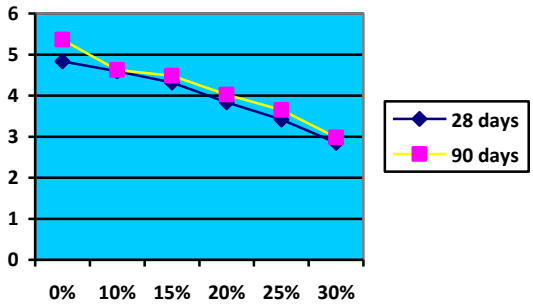

Chart 2-Flexural strength at 28 days and 90 days

B. Flexural Strength Of Concrete

The flexural strength of concrete is one of the most important and useful properties of concrete. It is generally determined by testing prisms of size 500mm x100mm x100 mm that was done in the lab. In this test, the prisms are subjected by applying the load of 1.8kN(180kg/min). Flexural test is intended to give the flexural strength of concrete in tension. The most common plain concrete is subjected to flexure is a highway pavement and the strength concrete for pavement is commonly evaluated by means of bending tests. The modulus of rupture is determined by testing prisms with four point loading in N/mm^2. For 100mm specimens, the load shall be increased until the specimen fails and the maximum load applied to the test shall be recorded. The appearance of the fracture faces concrete and any unique features in the type of failure shall be noted. It is calculated by [3Pa/bd^2] because a is less than 133 mm and greater than 100mm.

C.Modulus Of Elasticity

The modulus of elasticity of concrete is taken from the IS 456 and it is 27386 N/mm^2 and the poisons ratio is calculated from the IRC: SP:62-2004. And the value is taken as 0.15

VI. DESIGN OF RURAL ROADS-CEMENT CONCRETE PAVEMENTS (IRC:SP 62-2004)

A cement concrete pavement is to be designed for a rural road in Coimbatore district having a traffic volume up to 500 vehicles per day consisting of vehicle like light goods vehicles, tractors, buses, two wheelers and it is designed for village. The soil has a soaked CBR value of 4%.

Table 10:DESIGN OF RURAL ROADS – CC PAVEMENTS-10%

Traffic volume	Up to 500 cvpd(Assume)
Concrete grade (f_c)	30N/mm^2
Characteristic compressive cube strength	36.9 N/mm^2
Flexural strength (f_f)	4.59 N/mm^2
90 days flexural strength	4.62 N/mm^2
Soaked CBR value(%)	4%
Modulus of subgrade reaction (K)	35(N/mm^2/mm)*10^{-3}
Effective K value (20% more)	42(N/mm^2/mm)*10^{-3}
Elastic modulus of concrete	27386 N/mm^2
Poisson's ratio (μ)	0.15
Coefficient of thermal coefficient	0.00001/°C

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of concrete (α)	
Design wheel load (P)	30KN
Tyre pressure(q)	0.5N/mm^2 [5Kg/cm^2]
Spacing of contraction joints (L)	3.75m [3750mm]
Width of slab (W)	3.75m [3750mm]
Radius of load contract (assumed circular), a	13.82cm=138.2 mm

Check for Temperature stress:

Assuming a contraction joint spacing of 3.75m and 3.75m width

1.Temperature stress:

The temperature differential (Δt) for Coimbatore for a slab thickness of 190mm is 17.3°C.

From table 4: from SP62:2004

Radius of relative stiffness, $l = \frac{\sqrt[4]{Eh^3}}{12(1-\mu^2)K}$

$$l = \sqrt[4]{\frac{27386\times190^3}{12(1-0.15^2)(35\times10^{-3})}}$$

$$= \sqrt[4]{\frac{1.87\times10^{11}}{0.410}}$$

$$\boldsymbol{l = 820\ mm}$$

L/l = 3750/820 = 4.5

W/l = 3750/820 = 4.5

Both values are same, if not then adapt greater one

Bradbury's coefficient , C = 0.650 (from fig 1, pg 9) in SP62-2004

Temperature stress in edge region $\sigma_{te} = \frac{E\alpha\Delta t}{2} C$

$$\sigma_{te} = \left(\frac{27386*0.00001*17.3}{2}\right)0.650$$

σ_{te} = 1.53N/mm^2

2.Edge load stress (σ_μ)

σ_μ = 0.529 [30000/190^2] (1+0.54(0.15)) [4log$_{10}$(820/130)+log$_{10}$(130)-0.4048]

= 0.529*1.33*1.081*(2.89+2.13-0.4048)

= 0.760*4.52

σ_μ = 2.32 N/mm^2

Total stress = Edge load stress + Temperature stress

= 2.32+1.53

= 3.85 N/mm^2

Which is less than allowable flexural strength of 4.62 N/mm^2

Hence, assumed thickness of slab = 190mm, is OK (as per T.S criteria)

3.Check for Corner stress (σ_μ)

$$\sigma_\mu = \frac{3P}{h^2}\left[1-\left(\frac{a\sqrt{2}}{l}\right)^{1.2}\right]$$

= (3*30000)/190 ^{2} [1- ((138.2$\sqrt{2}$)/820)$^{1.2}$]

= 4*[1-0.22]

σ_μ = 2.46 N/mm^2

σ_μ = 2.46 N/mm^2 which is less than allowable flexural stress 4.62 N/mm^2 .

So, **the slab thickness of 190mm is safe.**

The calculations presented above are sample calculations. Similar calculations are done by using various values of flexural strength of concrete.

Table 11:Thickness of Slab

% of replacement	Slab thickness
0%	150
10%	190
15%	190
20%	190
25%	200
30%	250

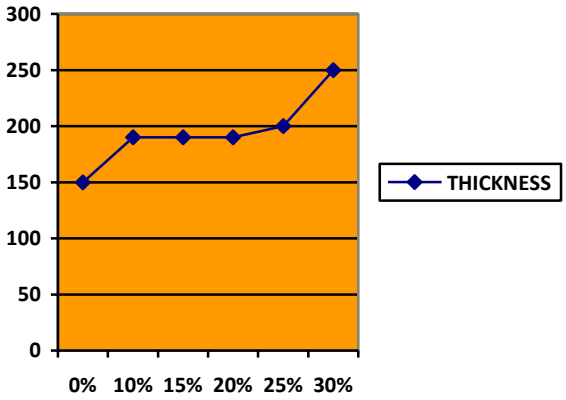

Chart 3: thickness of slab

VII. ECONOMIC ANALYSIS

Cement =350/bag

Sand =1500(m^3)

Aggregate =750(m^3)

Table 12 cost of materials

Materials	Qty	Unit	Rate	Amount
Cement	9	Bags	350	3150.00
Sand	0.46	m^3	1500	690.00
Aggregate	0.73	m^3	750	547.00
			Total	4387.00

Table 13 Materials for designed M30 concrete

% of replacement	Materials				Total cost
	Cement(kg/m^3)	Sand(kg/m^3)	aggregate(kg/m^3)	Hypo sludge(kg/m^3)	
0	425	684	1152	0	4387.5
10	382	667	1123	42.5	4000
15	361	660	1112	63.75	3694.56
20	340	650	1096	85	3250.32
25	318	643	1084	106	2970.63
30	297	634	1086	128	2563.20

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Table 14:Relative cost of slab

% of replacement	Slab thickness(cm)	Cost of slab(Rs)
0	15	800.80
10	19	898.69
15	19	898.69
20	19	898.69
25	20	890.00
30	25	768.00

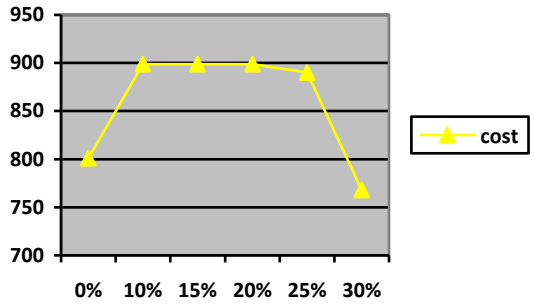

chart 4:cost of slab

VIII. CONCLUSION

- For a CBR value of 4% and wheel load (P) of 30kN. Cost of rigid pavement decreases from Rs.800.00 to Rs.768.00
- Use of hypo sludge in concrete can save the paper industry disposal costs and produce a greener concrete for low cost rural roads.
- In this research, it verifies that this concrete is considered as lower cost concrete. India should aggressively identify projects that can use large amounts of hypo sludge in road construction so that harmonizing environment and ecological sustainability can be developed.
- When hypo sludge is used in construction of road works will result in the less depletion of naturally materials and will save cement. By saving cement, it leads to reduction in construction cost.
- By certain results, road sector can use this hypo sludge on pavements , a huge demand can be expected for construction purposes. The judicious decisions should be taken from engineers, for the development of low cost rural roads.

IX. REFERENCES

[1] Gambir.M.L. "Concrete Technology "Tata McGraw Hill Company, New Delhi.
[2] Indian Standard code of Practice for plain and reinforced concrete.IS 456:2000,fourth revision, Bureau of Indian Standard, New Delhi.
[3] Indian Standard recommended guidelines for concrete mix design ,IS 10262-2009 ,Bureau of Indian Standards, New Delhi.
[4] Indian Standard Specification For course aggregate and Fine aggregate from natural sources for concrete ,IS 383:1970 ,Bureau of Indian Standards ,New Delhi.
[5] Indian Standard Specification For 53 grade ordinary Portland cement, IS 12269:1987, Bureau of Indian Standards ,New Delhi.
[6] Structural performance of concrete in partial replacement of paper waste, **Ram panth, Suresh pantil."(IJETE),** volume 1 , Issue 7, August 2014, ISSN 2348-8050.
[7] Study of concrete involving use of waste paper sludge ash as partial replacement of cement. **Sajad Ahmad,Rafiq Ahmad .**(ISOR).Vol 3,Issue 11,November 2013
[8] Structural performance and durability of concrete by partial replacement of hypo sludge **Hari Krishnan, vidyasagar lal.** (ISJOR)Vol4, Issue no 12 ,ISSN:2319-6890,Dec 2015
[9] Experimental investigation of partial replacement by industrial waste**. Bala murgan, karthickraja** ,IJERA ,ISSN :2248-9622,Vol 4,Issue 4,April 2014.
[10] Flexural Strength of Beams by Partial Replacement of Cement With Fly ash and Hypo sludge in Concrete.**Jayraj vinodsinhsolanki,Jayeshkumar Pitroda,** IJESIT,Vol 2,Issue1,January 2013.
[11] Durability Aspects of standard concrete, **Vijaya sekhar Reddy, Ramana Reddy,** (IJSCER),Vol 2, ISSN 2319-6009.
[12] ASTM C-1585, Standard test method for measurement of rate of absorption of water, American Society for Testing and Materials.
[13] ASTM C-1202, Standard test method for electrical induction of concrete ability to resist chloride ion penetration, American Society for Testing and Materials.
[14] Rushabh A. Shah, "Effect of Water Absorption and Sorptivity on Durability of Pozzocrete Mortar" (IJESE),vol 1Issue 5 March 2013,ISSN 2319-6378.
[15] Shetty M.S "Concrete Technology" "S.Chand & company",India
[16] Khanna S "Highway Engineering" "New Chand & Co", Roorkee, India
[17] Hiren A. Rathod, " A study of future trend for Sustainable development by Incorporation of SCM, (IJSR), volume 2 Issue 2,ISSn :2277-8179.
[18] Guidelines For The Design And Construction Of Cement Concrete Pavements For Rural Roads , IRC:SP:62-2004.

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