AN EXPERIMENTAL STUDY ON USE OF HYPO SLUDGE IN CEMENT CONCRETE

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ABSTRACT

For sustainable development, among others, protection of environment is one of the major challenges. In order to reduce the consumption of natural resources, which are limited, use of industrial wastes to replace fresh materials is one of the viable options to control degradation of environment.

Millions of tonnes of solid industrial wastes are produced in India every year. A large quantity of this is contributed by paper industry where three kinds of wastes are generated, i.e. , fibrous sludge called reject which is bio-degradable, Hypo sludge, solid wastes generated during calcium hypo chlorite generation and Lime sludge, generated during causticisation of green liquor. The hypo sludge and lime sludge are purely chemical wastes and require large spaces of landfill for their disposal. Limited land fill sites augment the disposal problems of these wastes.

Use of these wastes in cement concrete can not only solve the problem of their disposal but economize the concrete by partially replacing cement. Response to various loads and durability of such concretes might be prime concern of construction engineers, structural designers and owner of the structure. Therefore, a scientific experimental study of such concretes is inevitable.

This paper presents the test results of chemical and physical analysis investigating the utilization of hypo sludge, lime sludge and fly ash in cement concrete. Chemical analyses have been conducted, to evaluate optimum proportions of these materials to be used in concrete following direct enumeration method. Study shows some important parameters such as workability, cube strength, stress-Strain characteristics (cylinder), modulus of elasticity and failure patterns for M20 (1:1.5:3) mix with 10%, 20%, 30%, 40% cement replacement with hypo sludge and comparison with that of conventional cement concrete.

Keywords: Sustainable Development, Hypo sludge, Lime sludge, Fly ash.

I. INTRODUCTION:

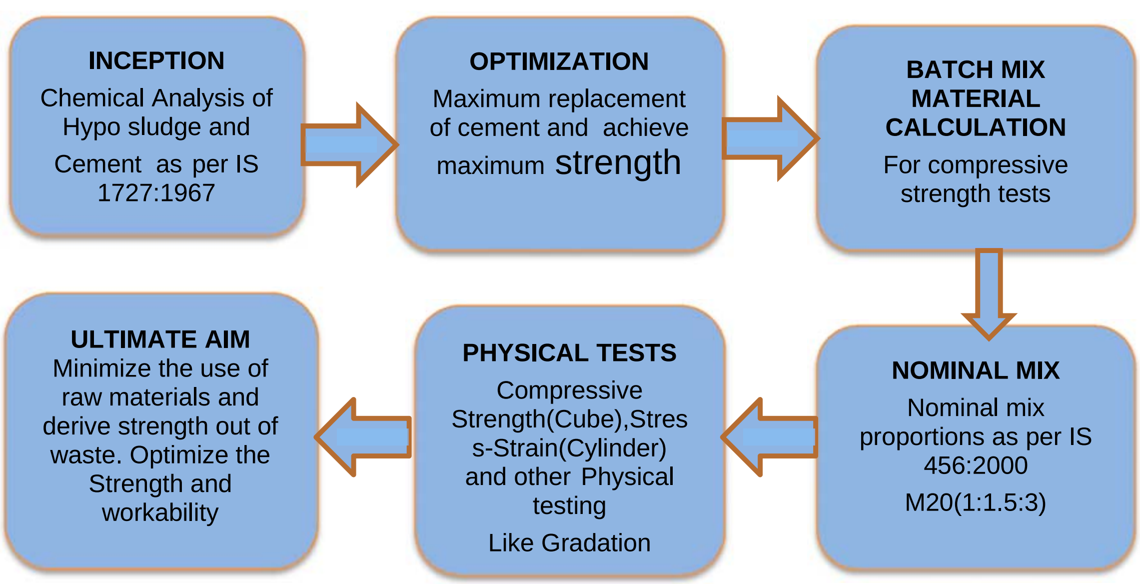
Natural resources are not unlimited therefore, they must be optimally consumed. This shall help not only to control degradation of environment but conserve them also for the use of future generation. This can be achieved by the process of recycling and, making use of industrial wastes, disposal of which otherwise is a serious problem. Hypo sludge is such an industrial waste produced in plenty by paper mills. Construction industry is found to be apprehensively reluctant to use wastes for making concrete mixes. This paper presents the physical and chemical analysis of hypo sludge and its use in cement concrete as a partial substitute of cement which economizes the cost of concrete. Objective of this experimental study was to find out the important parameters such as compressive strength, modulus of elasticity, strain at maximum load and ultimate strain of cement concrete in which hypo sludge replaced the cement by 10, 20, 30 and 40 percent for certain slump workability and to find out the optimum percentage of hypo sludge in M20 nominal mix concrete. 100 mm slump has been considered for different replacement levels of cement. Two decision variables that are strength and workability had been considered to optimize the replacement percentage.

II. SOURCE OF HYPOSLUDGE:

The process of formation of paper from pulp includes the following processes during which the Hypo sludge is formed as waste by-product is purely a chemical wastes and do not contain any bio-degradable element**.** Most of the mills are using only woody raw material (bamboo, eucalyptus, casuarinas, poplar and other hardwood species), but some other mills are using bagasse in substantial quantity as raw material.

Most of the paper mills in India prepare bleach liquor (calcium hypochlorite) using lime and elemental chlorine. Six mills among eight mills are using ClO_2 as bleaching agent either as partial substitution of elemental chlorine or in final stage of bleaching to attain desired brightness level. These mills are producing ClO_2 with environmental friendly process. Three mills among eight mills are still using calcium hypo chlorite in final stage for bleaching. Solid wastes generated during calcium hypo chlorite generation are called hypo sludge.

III. METHODOLOGY



IV. CHEMICAL ANALYSIS

IS-1727:1967 "Test Methods for Pozzolanic Materials" had been followed for chemical analysis of the hypo-sludge and cement. Table 1 gives the results of chemical analyses.

Table 1: Results of Chemical Analysis

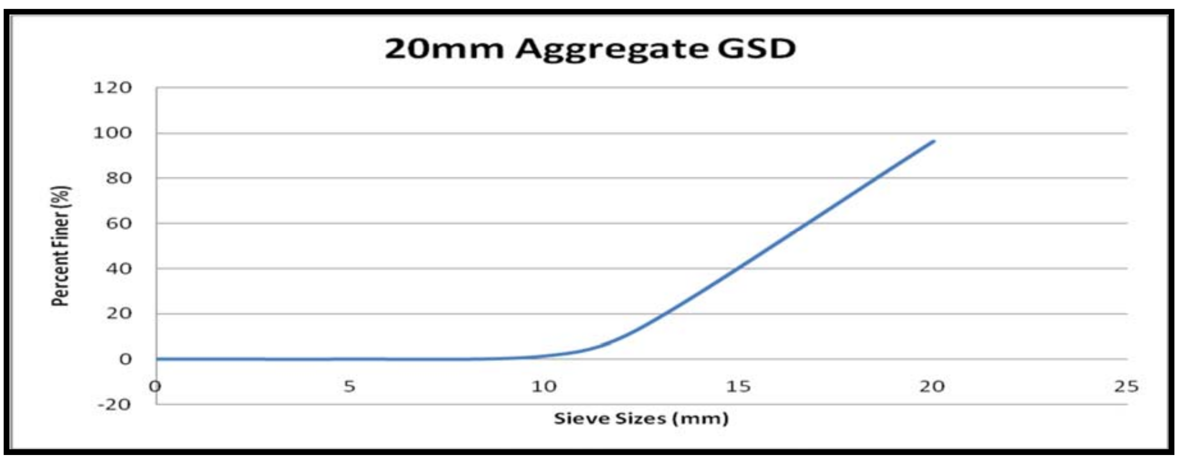
S. No.	Constituent	Hypo sludge (%)	Cement (%)
1.	**Silica**	3.0175	18.175
2.	**R_2O_3**	9.64	7.16
3.	**Calcium oxide**	43.17	63.26
4.	**Magnesia**	2.85	3.07
5.	**Loss of ignition**	1.78	0.57

- Inference From Chemical Analysis:

  Following inference can be drawn from the results of chemical analyses of cement and hypo-sludge.

  - The Hypo sludge procured seems to be a comparable material to cement on the basis of above tabled parameters which are responsible for the development of strength in cement.
  - The silica, calcium oxide, alumina, ferric oxide and magnesia content in hypo sludge are very desirable.
  - Hypo sludge is the most suitable material as a replacement of cement.

V. GRADATION



(GSD= GRAIN SIZE DISTRIBUTION)

Table 2A: Sieve Analysis of 20 mm aggregate (Weight of sample taken **= 2 Kg)**

Sieve Size (mm)	**Weight Retained (Kg)**	**Percent Weight Retained (%)**	**Cumulative Percent Weight Retained(%)**	**Percent Passing or Finer (%)**	**Fineness Modulus (FM)**
20	0.074	3.7	3.7	96.3	
12.5	1.65	82.5	86.2	13.8	
10	0.249	12.45	98.65	1.35	**FM = Σ Column 4 / 100**
4.75	0.027	1.35	100	0	
2.36	0	0	100	0	
1.18	0	0	100	0	
0.6	0	0	100	0	
0	0	0	100	0	= 6.89

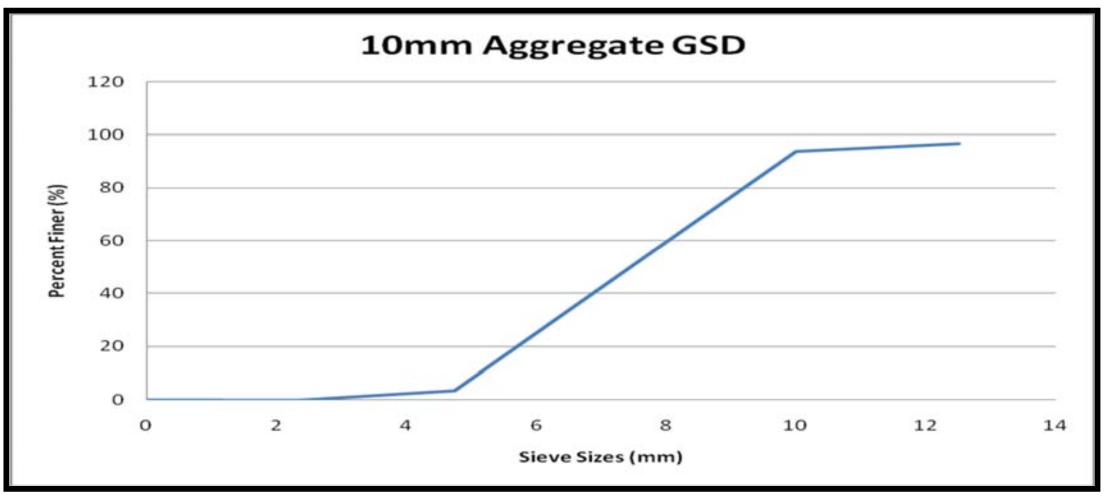


Table 2B: Sieve Analysis of 10 mm aggregate (Weight of sample taken **= 2 Kg)**

Sieve Size (mm)	Weight Retained (Kg)	Percent Weight Retained (%)	Cumulative Percent Weight Retained(%)	Percent Passing or Finer (%)	Fineness Modulus (FM)
12.5	0.062	3.1	3.1	96.9	
10	0.056	2.8	5.9	94.1	
4.75	1.81	90.5	96.4	3.6	FM = **Σ Column 4** / **100**
2.36	0.072	3.6	100	0	
1.18	0	0	100	0	
0.6	0	0	100	0	
0.3	0	0	100	0	
0	0	0	100	0	= 6.05

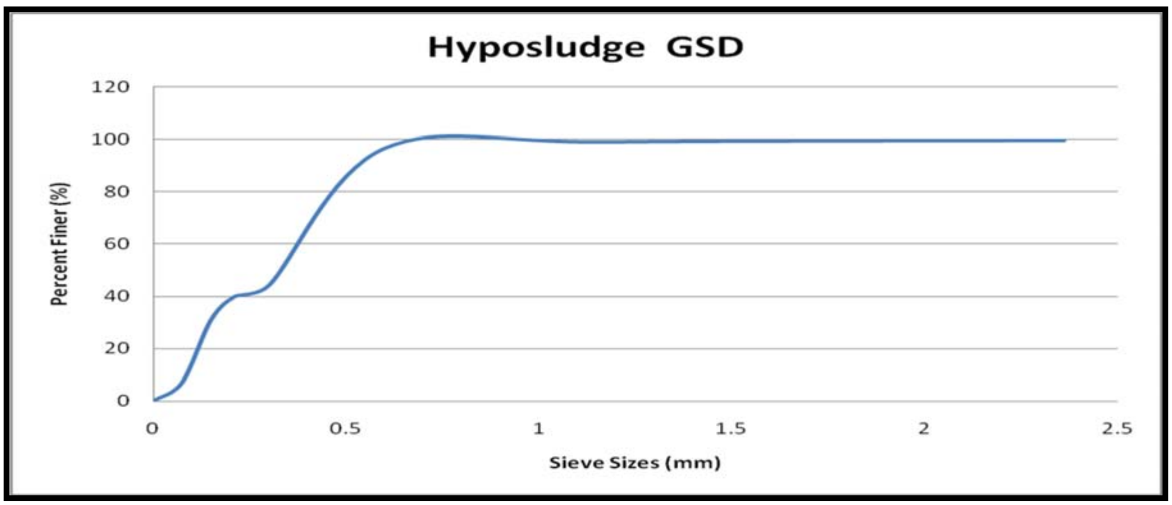


Table 2C: Sieve Analysis of Hypo sludge (Weight of sample taken = **1Kg)**

Sieve Size (mm)	Weight Retained (Kg)	Percent Weight Retained (%)	Cumulative Percent Weight Retained(%)	Percent Passing or Finer (%)	Fineness Modulus (FM)
2.36	0.002	0.2	0.2	99.8	
1.18	0.006	0.6	0.8	99.2	FM = **Σ Column 4** / **100**
0.6	0.024	2.4	3.2	96.8	

0.3	0.526	52.6	55.8	44.2	
0.212	0.042	4.2	60	40	
0.15	0.09	9	69	31	
0.075	0.24	24	93	7	
0	0.07	7	100	0	= 3.82

VI. BATCH MIX MATERIAL QUANTITY CALCULATION - M20 (1:1.5:3)

Table 3: Quantity Calculation for Batch

Material	Weight (Kg)	Batch	Water-Cement ratio (w/c)	Plasticizer percentage by weight of cement (%)	Mix Proportions	Slump (mm)
Cement	26.498	**0%**	**0.55**	**0**	**1 : 1.5 : 3**	**100**
Water	14.5739					
Sand	39.747					
20mm	39.747					
10mm	39.747					
Hyposludge	0					
Cement	23.85	**10%**	**0.55**	**0.8**	**1 : 1.5 : 3**	**100**
Water	14.5739					
Sand	39.747					
20mm	39.747					
10mm	39.747					
Hyposludge	2.651					
Cement	21.196	**20%**	**0.55**	**0.9**	**1 : 1.5 : 3**	**98**
Water	14.5739					
Sand	39.747					

20mm	39.747					
10mm	39.747					
Hyposludge	5.306					
Cement	18.557	**30%**	**0.55**	**1.0**	**1 : 1.5 : 3**	**97**
Water	114.574					
Sand	39.747					
20mm	39.747					
10mm	39.747					
Hyposludge	7.952					
Cement	15.900	**40%**	**0.67**	**1.0**	**1 : 1.5 : 3**	**100**
Water	17.507					
Sand	39.747					
20mm	39.747					
10mm	39.747					
Hyposludge	10.598					

Figure 4: Cylindrical Specimen being tested in compression testing machine after being capped using artite powder

VII. OBSERVATION TABLE

Table 4A: 7 day Cube Strength

S.No.	Cement Replacement Percentage (%)	Sample	Load (kN)	Mean Maximum stress (MPa)
(1)	0	M20-0%	435.94	19.30
(2)	10	M20-10%	499.30	22.16
(3)	20	M20-20%	433.00	19.24
(4)	30	M20-30%	334.47	14.86
(5)	40	M20-40%	167.40	7.45

Table 4B: 28day Cube Strength

S.No.	Cement Replacement Percentage (%)	Sample	Load (kN)	Mean Maximum stress (MPa)
(1)	0	M20-0%	434.22	19.37
(2)	10	M20-10%	586.3	25.52
(3)	20	M20-20%	528.03	23.45
(4)	30	M20-30%	350.87	15.59
(5)	40	M20-40%	220.17	9.71

Table 4C: 7 **day** Cylinder Strength

S.No.	Cement Replacement Percentage (%)	Sample	Load (kN)	Mean Maximum stress (MPa)
(1)	0	M20-0%	270.17	15.28
(2)	10	M20-10%	389.40	22.04
(3)	20	M20-20%	274.03	15.48
(4)	30	M20-30%	218.60	12.36
(5)	40	M20-40%	101.30	5.73

Table 4D: 28 day Cylinder Strength

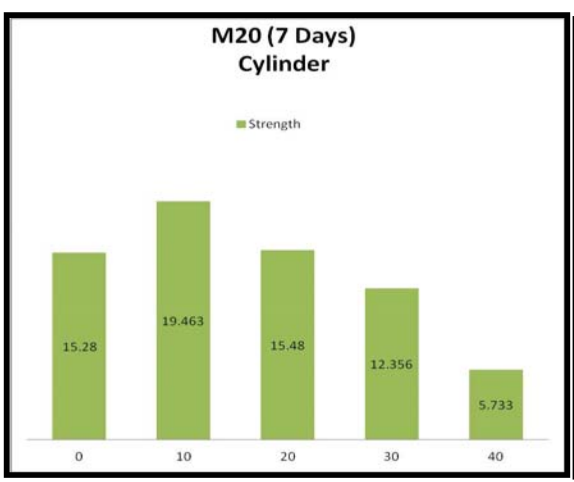
S.No.	Cement Replacement Percentage (%)	Sample	Load (kN)	Mean Maximum stress (MPa)	Mean Tangent Modulus (MPa)
(1)	**0**	M20-0%	**338.90**	**19.18**	$2.3950*10^4$
(2)	**10**	M20-10%	**344.13**	**19.46**	$2.4150*10^4$
(3)	**20**	M20-20%	**367.10**	**19.48**	$2.4121*10^4$
(4)	**30**	M20-30%	**251.30**	**14.20**	1.9040*104
(5)	**40**	M20-40%	**138.20**	**7.82**	2.4150*104

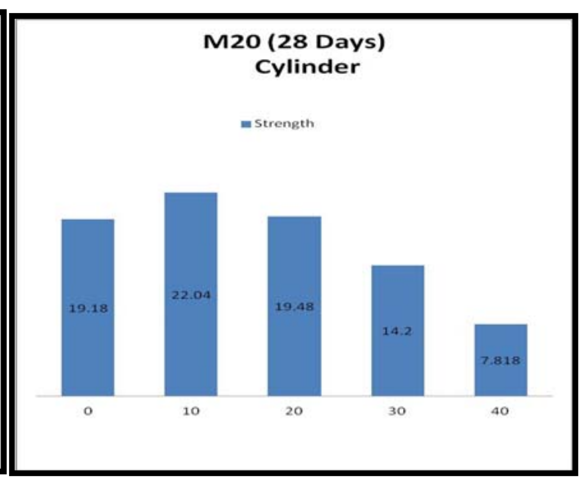
VIII. RESULTS:

Table 5: Results of the experimental study conducted is summarized in table below

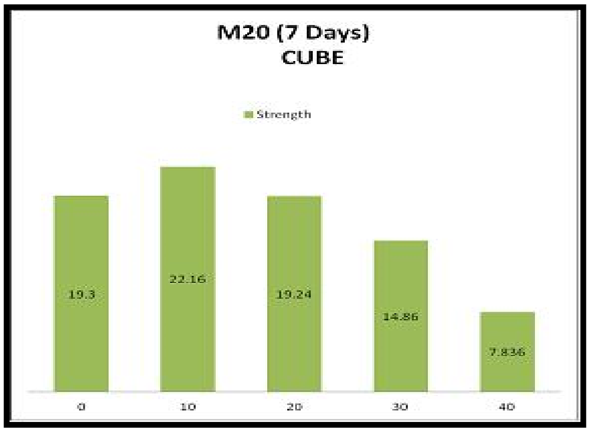
AGE OF SPECIMEN	STRENGTH (MPa)				
	0 %	**10%**	**20%**	**30%**	**40%**
7 Day Cube	**20**	**22.2**	**19.24**	**15**	**8**
28 Day Cube	**23.5**	**26.05**	**23.46**	**15.6**	**9.8**
7 Day Cylinder	**15.28**	**19.463**	**15.48**	**12.356**	**5.733**
28 Day Cylinder	**19.18**	**22.04**	**19.48**	**14.2**	**7.818**
PLASTICIZER	**0**	**0.8%**	**0.9%**	**1%**	**1%**

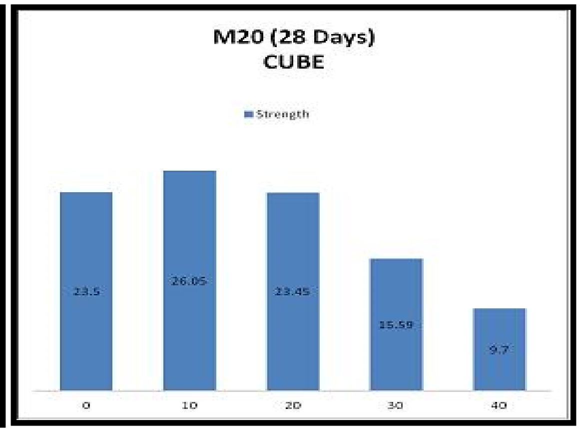
- **Comparison of Cylinder Strength (M 20)**





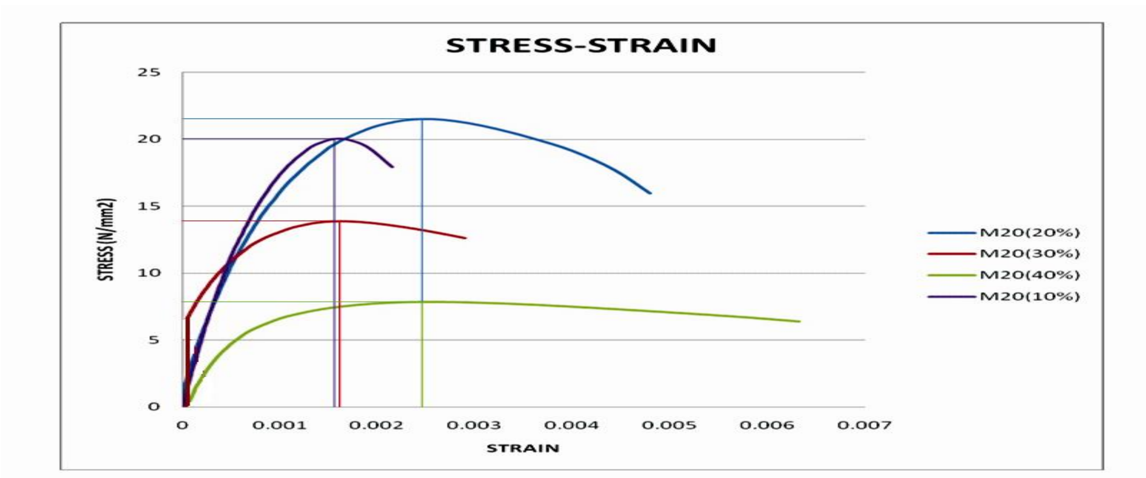
- **Comparison of Cube Strength (M 20)**





- The comparison of cube and cylinder strengths shown above for different cement replacement levels by hyposludge are having units **MPa** or **N/mm^2**

- **Comparison of Stress-Strain Curves for Cylinder (M 20)**



- **Cost Analysis (M20 (1:1.5:3))**

Cost of one bag of cement (50kg) = 300 Rs.

One cubic meter of concrete contains = 436 kg of cement

Percentage of hypo-sludge will be used = 20%

Quantity of hypo-sludge will be used in one cubic meter of concrete = 87.2 kg

Since the cost of hypo-sludge is negligible, so it can widely be used in areas near by paper mill.

Amount of money saved in one cubic meter of concrete = Rs 523

IX. CONCLUSIONS: For M20 (nominal mix) concrete

- **Workability:**
  - Experiments reveal that as the percentage of hypo-sludge in the mix increases the slump decreases.

- **28 day Cube strength:**
  - 20% replacement of cement by hypo-sludge gives as much strength as pure cement concrete.
  - 10% replacement of cement by hypo-sludge gives about 11% higher strength than pure concrete.
- **Hypo-sludge** which is available in abundance in the vicinity of every paper mill is not a waste but a useful material which can be used in concrete manufacturing. Its application in concrete manufacturing:
  - Helps to some extent in preserving the environment as its application reduces the requirement of cement's raw material.
  - Solves its problem of disposal.
  - Economises the cost of concrete.

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