Utilization Of Hyposludge In Normal Concrete

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ABSTRACT

Utilization of industrial waste products as supplementary cementitious materials (SCM) in concrete making is very important aspect in view of economical, environmental and technical reasons. As these supplementary cementitious materials have different chemical and mineralogical composition, there effect on micro structural properties and strength performance vary considerably.

While producing paper various wastes are comes out from the various processes in paper industries. The preliminary waste from paper industry is named as hypo sludge. In this study the material obtained from the paper industry waste (hypo sludge) is admixed with Portland cement at different replacement levels. The properties of concrete to be investigated include workability, setting time, compressive strength, optimum percentage of hypo sludge as supplementary cementitious material (SCM).

This report summarizes the various efforts underway to improve the environmental friendliness of concrete to make it suitable as a "Green Building" material. Foremost and most successful in this regard is the use suitable substitutes for Portland cement, especially those that are byproducts of industrial processes, like fly ash, ground granulated blast furnace slag, and silica fume. The combination of different binders and modifiers to produce cheaper and more durable building materials will solve to some extent the environmental and ecological problems.

1.1 Introduction

The environmental aspects involved in the production of and use of cement, concrete and other building materials are of growing importance. Producing one tonne of cement results in the emission of approximately one tonne of CO_2. SO_2 emissions is also very high, but is dependent upon the type of fuel used .Energy consumption is also very high at 90-150 KWT/ton of cement produced. It is costly to erect new cement plants. Substitution of waste materials will conserve resources, and will avoid environmental and ecological damages caused by quarrying and exploitation of the raw materials for making cement. While the developed, industrialized countries are called upon to reduce pollution of the environment and their share of the usage of the world's resources, including energy, the developing countries need to avoid the mistakes of the past. This problem is particularly acute, since cement production as well as fly ash generation in China and India are expected to increase significantly in the next few decades. There is an increasing demand for concrete worldwide, estimated to double within the next 30 years. This demand can be met without a corresponding increase in greenhouse gases by using supplementary cementitious materials to replace a maximum amount of the cement in concrete; we can reduce energy and resource consumption, reduce CO_2 emissions, and reduce the negative environmental impact. There is a further environmental benefit in that most commonly used supplementary cementitious materials (such as hypo sludge, fly ash, silica fume) are waste products and would otherwise end up in landfills.

Paper making generally produces a large amount of solid waste. It means that the broken, low-quality paper fibers are separated out to become waste sludge. This paper mill sludge consumes a large percentage of local landfill space every year and also contributes to serious air pollution problems. To reduce disposal and pollution problems emanating from these industrial wastes, it is most essential to develop profitable building materials from them. Partial replacement of cement can be made by hypo sludge, fly ash, silica fumes and natural rock minerals. Partial replacement by natural rock minerals that require little or no processing, saves energy, and decreases emission of gases. The output of waste materials suitable as cement replacement (hypo sludge, fly Ash, silica fumes etc.) is more than double that of cement production. Use of waste products is not only a partial solution to environmental and ecological problems, it significantly improves the microstructure, and consequently the durability properties of concrete, which are difficult to achieve by the use of pure Portland cement. The aim is not only to make the cement and concrete less expensive, but to provide a blend of tailored properties of waste materials and Portland cements suitable for specified purposes. This requires a better understanding of chemistry, and material science. This report concisely explains the technical and environmental benefits of supplementary cementations' materials use, as well as the limitations, applications and specifications.

1.2 Constituents of Concrete

Concrete is a construction material composed of cement as well as other cementitious materials such as fly ash, hypo sludge and slag cement, aggregate. Concrete is basically a mixture of two components: aggregates and paste. The paste is usually composed of Portland cement and water, and it binds together the fine and coarse aggregates. Supplementary cementing materials may also be included in the paste. A typical mix is about 10 to 15 percent cement, 60 to 75 percent sand/aggregate, 10 to 20 percent water and 5 to 8 percent air. Concrete solidifies and hardens after mixing with water and placement due to a chemical process known as hydration. The water reacts with the cement, which bonds the other components together, eventually creating a stone-like material. Concrete is used to make pavements, pipe, architectural structures, foundations, motorways/roads, bridges etc.The different constituents of cements are presented in Figure

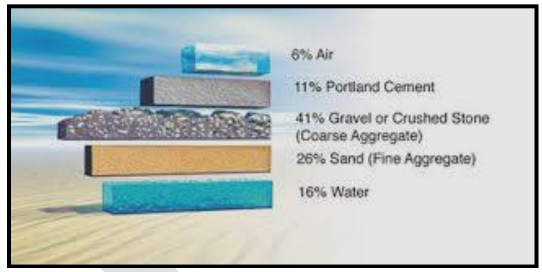


Figure 1.1 Constituents of concrete

1.2.1 Cement

Cement is the most important constituent of concrete. In that, it forms the binding medium for the discrete ingredient. The Chemical composition of cement is presented as follows. Lime (CaO) 60-67 (SiO_2) 17 -25, Alumina (Al_2O_3) 3-8, Calcium sulphate ($CaSO_4$) 3-4, Iron oxide (Fe_2O_3) 3-4, Magnesia (MgO) 0.5 - 4,Sulphur trioxide (SO_3) 1-2% and Alkalis <1 percent. Portland cement is composed of calcium silicates and aluminates. It is obtained by blending predetermined proportions of limestone, clay and other minerals in small quantities, which is pulverized and heated at high temperatures around 1500^0 C to produce 'clinker'. The clinker is then ground with small quantities of gypsum to produce fine powder called ordinary Portland cement (OPC). When mixed with water, sand and stone, it combines slowly with the water to form a hard mass called concrete. Cement is a hygroscopic material meaning that it absorbs moisture. In presence of moisture it undergoes chemical reaction termed as hydration. Therefore cement remains in good condition as long as it does not come in contact with moisture. If cement is more than three years old then it should be tested for its strength before being taken it for use.

The Bureau of Indian Standards (BIS) has classified OPC in three different grades .The classification is mainly based on the compressive strength of cement-sand mortar cubes composed of 1part of cement to 3 parts of standard sand by weight with water-cement ratio arrived at by a specified procedure. There are different types of cements are available in the market .The following are the three main grades as presented below.

- 33 grade
- 43 grade
- 53 grade

The grade number indicates the minimum compressive strength of cement sand mortar in N/mm^2 at 28 days.

1.2.2. Aggregate

Aggregates which occupy nearly 60 to 75 percent volume of concrete. Fine and coarse aggregates make up the bulk of a concrete mixture. Sand, natural gravel and crushed stone are mainly used for this purpose.

1.2.3 Water

Combining water with a cementitious material forms a cement paste by the process of hydration. Less water in the cement paste will yield a stronger, more durable concrete; more water will give a free-flowing concrete with a higher slump. Impure water used to make concrete can cause problems when setting or in causing premature failure of the structure. The pH value of water should not be less than 6. Hydration involves many different reactions, often occurring at the same time. As the reactions proceed, the products of the cement hydration process gradually bond together the individual sand and gravel particles, and other components of the concrete, to form a solid mass.

1.2.4 Chemical Admixtures

Chemical admixtures are materials in the form of powder or fluids that are added to the concrete to give it certain characteristics not obtainable with plain concrete mixes. In normal use, admixture dosages are less than 5% by mass of cement, and are added to the concrete at the time of batching/mixing. The most common types of admixtures are:

- Accelerators : speed up the hydration (hardening) of the concrete
- Retarders: slow the hydration of concrete, and are used in large or difficult pours where partial setting before the pour is complete is undesirable.
- Plasticizers/super plasticizers (water-reducing admixture) increase the workability of plastic or "fresh" concrete, allowing it is placed more easily, with less consolidating effort. Alternatively, plasticizers can be used to reduce the water content of a concrete (have been called water reducers due to this application) while maintaining workability. This improves its strength and durability.
- Pigments: can be used to change the color of concrete, for aesthetics.
- Corrosion inhibitors: are used to minimize the corrosion of steel bars in concrete.
- Bonding agents are used to create a bond between old and new concrete.

1.3 PROPERTIES OF CONCRETE

Concrete is a mixture of cement, sand, stone aggregates and water. Concrete has two main stages. Among first one is Fresh concrete and secondly hardened concrete

1.3.1 Fresh Concrete

It should be stable and should not segregate or bleed during transportation and placing when it is subjected to forces during handling operations. The mix should be cohesive enough to be placed in the form around the reinforcement and should be able to cast into the required shape without losing homogeneity under the available techniques of placing the concrete at a particular job.

1.3.2 Hardened Concrete

It is one of the most important properties of the hardened concrete is its strength which represents the ability if it resist forces. The compressive strength of hardened concrete is generally considered to be the most important property and is often taken as the index of the overall quality of concrete.

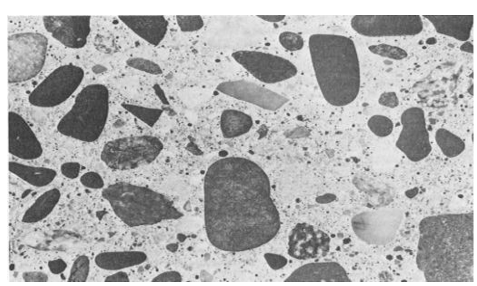


Figure 1.2 Hardened Concrete Structures

1.3.3 Workability

It is defined as the ease with which the concrete is handled, transported and placed so that concrete remains homogenous. Workability depends on water content, aggregate (shape and size distribution), cementitious content and age and can be modified by adding chemical admixtures. Raising the water content or adding chemical admixtures will increase concrete workability. Excessive water will lead to increased bleeding (surface water) and/or segregation of aggregates with the resulting concrete having reduced quality. Workability of concrete may be determined by slump test, compaction factor test.

1.3.4 Compactability

It is the ease with which concrete can be compacted. In other words, it is the amount of internal work required to produce complete compaction. The addition of admixtures greatly increases compactability.

1.3.5 Stability

The ability of concrete to remain a stable, homogeneous mass without segregation both during handling and during vibrations is termed as stability.

1.3.6 Segregation

It can be defined as separating out of the ingredients of a concrete mix, so that the mix is no longer in a homogeneous condition. Only the stable homogeneous mix can be fully compacted. It can be minimized by adding small quantity of water which improves the cohesion of the mix.

1.3.7 Bleeding

It is due to the rise of water in the mix to the surface because of the inability of the solid particles in the mix to hold all the particles under the effect of compaction. The bleeding causes formation of a porous, weak and non durable concrete layer at the top of placed concrete.

1.3.8 Curing

Curing means maintaining a satisfactory moisture content and temperature in concrete in order to achieve the desired strength and hardness. Drying removes the water needed for hydration. Without adequate water and due to insufficient hydration, concrete tends to be weak. Temperature is an important parameter to consider for proper curing.

1.4 History and importance of Sludge

Paper making generally produces a large amount of solid waste. Paper fibres can be recycled only a limited number of times before they become weak to make high quality paper. This paper mill sludge consumes a large percentage of local landfill space for each and every year. To reduce disposal and pollution problems from these industrial wastes, it is most essential to develop profitable building materials from them. 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

1.5 Need for the present study:

This study includes different concrete mixtures were produced to determine the influence of hypo sludge. It is very essential to dispose these wastes safely without affecting health of human being, environment, fertile land, sources of water bodies, etc. These wastes have number of impurities which adversely affect the strength, durability, and other properties of building materials based on them. Paper producing industries produce a large amount of solid waste. For achieving high quality paper, the fibers which are used a limited number of times till they reach their weak stage. Many companies burn their sludge in incinerators which leads towards air pollution. So the paper presents the management of the wastes coming from paper industries.

1.6 Objectives of the present study:

To reduce disposal and pollution problems emanating from these industrial wastes, it is most essential to develop profitable building materials from them. Keeping this in view, investigations were undertaken to produce low cost concrete by blending various ratios of cement with hypo sludge. This project is concerned with experimental investigation on strength of concrete and optimum percentage of the partial replacement by replacing cement *via* 10%, 20%, 30%, and 40% of Hypo Sludge.

6.1 RESULTS AND ANALYSIS

It includes analysis on

(i)Results

(ii)Graphical interpretation

(iii)Mix design

(iv)Cost Analysis

6.2 TEST RESULTS

Compressive strength of 15cm X 15cm concrete cubes

Table - 6.1 Compressive strength of cubes at 14 days

Compressive strength of cubes at 14 days				
Partial replacement of hypo sludge in %	**No of Cubes**	**Initial Crack Load(kN)**	**Ultimate crushing Load(kN)**	**Ultimate Compressive Strength (N/mm^2)**
0	3	163	392	17.20
10	3	184	401	17.80
20	3	192	423	18.87
30	3	224	453	20.07
40	3	145	345	15.33
50	3	135	295	13.11

Table - 6.2 Compressive strength of cubes at 28 days

Compressive strength of cubes at 28 days				
Partial replacement of hypo sludge in %	**No of Cubes**	**Initial Crack Load(kN)**	**Ultimate crushing Load(kN)**	**Ultimate Compressive Strength (N/mm^2)**
0	3	181	498	22.14
10	3	199	522	23.18
20	3	230	537	23.85
30	3	255	567	25.18
40	3	160	420	18.70
50	3	145	379	16.81

Note: HS: Hypo sludge; C: Cement

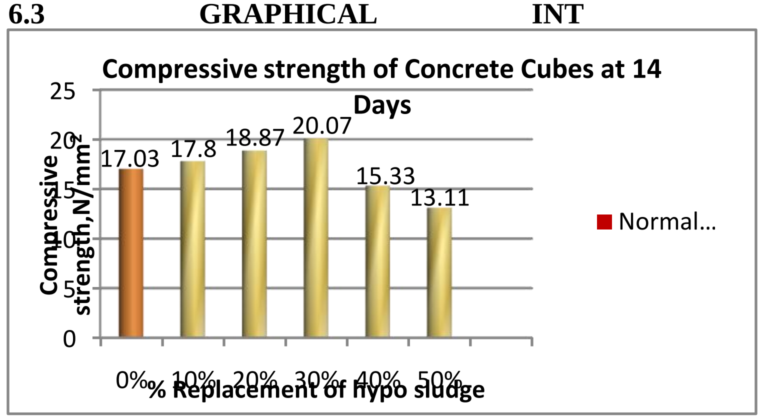
1) It is observed that hypo n (90% + 10%) proportior s higher compressive strength compared to the conventional concrete. The percentage increase in strength as compared to conventional concrete is 4.7%

2) It is observed that hypo sludge concrete with (80% + 20%) proportion of (HS+C) shows higher compressive strength compared to the conventional concrete. The percentage increase in strength as compared to conventional concrete is 7.7 %

3) It is observed that hypo sludge concrete with (70% + 30%) proportion of (HS+C) shows higher compressive strength compared to the conventional concrete. The percentage increase in strength as compared to conventional concrete is 13.7 %

4) It is observed that hypo sludge concrete with (60% + 40%) proportion of (HS+C) shows higher compressive strength compared to the conventional concrete. The percentage decrease in strength as compared to conventional concrete is 15.5%

6.3 GRAPHICAL INT

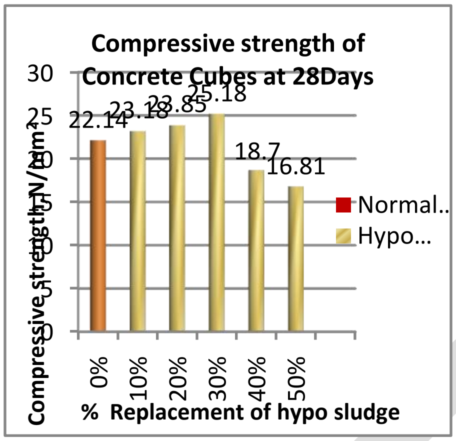


ERPRETATION OF TEST RESULTS

Graph - 6.1 Compressive strength of cubes at 14 days

Graph - 6.2 Compressive strength of cubes at 28 days

Concrete



6.4 I.S. METHOD OF MIX DESIGN (M_{20}) ANALYSIS

1. Requirements

a) Specified minimum strength = 20 N/mm^2
b) Durability requirements
i) Exposure Moderate
ii) Maximum W/C ratio = 0.50
iii) Minimum grade of concrete = M_{20}

c) Cement
i)Type of cement = OPC (53 Grade)
ii)Brand of cement = Anjani super gold

d)Workability
i) Slump value 130mm

e) Degree of quality control: Good

2. Test data of materials used

a) Cement
i) Specific gravity = 2.81
ii) Normal consistency = 30
ii) Avg. compressive strength for 7days = 39N/mm^2

b) Coarse aggregate
i) Grade 20mm
Type: Crushed stone aggregate
Specific gravity = 2.52
Impact value = 25.72

c) Fine aggregate
Type: River sand

3. Target mean strength (TMS)
Target Mean Strength $f_t = f_{ck} + K \times S.D$
Where f_{ck} is Characteristic strength of concrete = 20
K is Statistical Constant = 1.65
S.D is Standard Deviation = 4
Thus TMS = 26.60N/mm^2

4. Selection of w/c ratio
a) As required for TMS = 0.5
Assume w/c ratio of 0.45 (or) 0.5

5. Determination of water content
Required water content = 190.80 kg/m^3

6. Determination of admixture content
Type of Admixture = CONPLAST P211 (M)
Adopted amount of admixture = 0.5% of cement

7. Determination of cement content
Required Cement content = 424kgs

8. Determination of fine and coarse aggregate content
Total mass of fine aggregate = 636kgs
Total mass of coarse aggregate = 1272kgs

Mix Proportions:

Water	Cement	Fine aggregate	Coarse aggregate
190.80	424	636	1272

Units: kg/m^3

6.5 COST ANALYSIS
Cost analysis is carried out for the optimum proportion of percentage of hypo sludge in

concrete. The cost of conventional concrete is compared with hypo sludge concrete.

Cost of materials

Cost of cement per tonne = Rs.4000.00

Cost of sand per tonne = Rs.650.00

Cost of hypo sludge per tonne = Rs.500.00

Cost of coarse aggregate per tonne = Rs.370.00

Cost of admixture per liter = Rs.100Table – 6.3

Cost analysis of conventional concrete materials

Cost of material of conventional concrete/ m^3			
Description	Quantity kg/m^3	Cost(Rs.)	Cost of material(Rs.)
Cement	424	4000/t	1696
Hypo sludge	-	500/t	-
Fine aggregate	636	650/t	41
Coarse aggregate	1272	370/t	470.64
Admixture	2.12	100/liter	212
Total Cost			2792.04

Therefore the cost of conventional concrete is Rs.2792.04

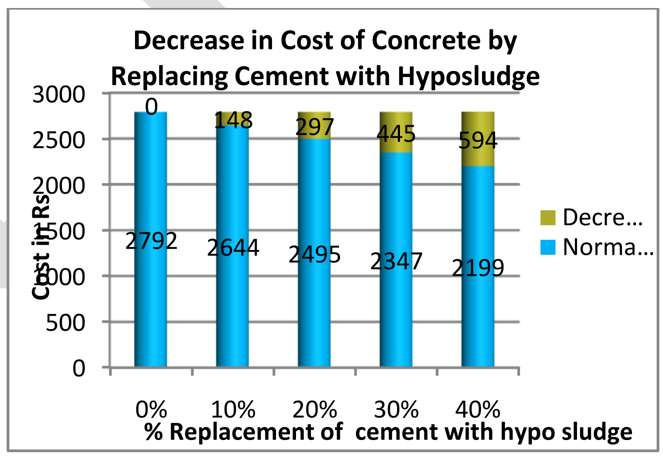
The cost of hypo sludge concrete /m^3 @ 10 % replacement of hypo sludge is Rs.2643.64

The cost of hypo sludge concrete /m^3 @ 20 % replacement of hypo sludge is Rs.2495.24

Table – 6.4 Cost analysis of partially replaced concrete materials

Cost of hypo sludge concrete/ m^3 @ 30% replacement of hypo sludge			
Description	Quantity kg/m^3	Cost(Rs.)	Cost of material(Rs.)
Cement	296.8	4000/t	1187.2
Hypo sludge	127.2	500/t	63.6
Fine aggregate	636	650/t	413.4
Coarse aggregate	1272	370/t	470.64
Admixture	2.12	100/liter	212
Total Cost			2346.84

The compared values of cost show gradual decrement in total cost of per cubic meter concrete. The above table shows cost values up to 30% replacement and the **difference in cost** from conventional concrete to partially replaced concrete was **Rs.445.**



Graph - 6.3 Decrease in cost of concrete by replacing cement with hypo sludge

CONCLUSIONS

Based on experimental investigation on the “compressive strength of concrete” and considering the “environmental aspects” the following observations are made regarding the resistance of partially replaced hypo sludge.

- ✓ From the observation of graphs of compressive strength of concrete, replacement of cement with the hypo sludge material provides maximum compressive strength at 30% replacement.
- ✓ Environmental effects can be minimized and the usage of cement can be minimized through this project.
- ✓ It is observed that the density of hypo sludge concrete is less compared to that of normal concrete. Therefore hypo sludge concrete can be used as lightweight concrete.
- ✓ This material can be used for construction of temporary shelters during natural calamities.
- ✓ But in economy point of view, the cost of concrete can be reduced by replacing cement with hypo sludge. As per IS 456-2000 the cost of normal concrete can be reduced up to 445/m^3 for M_{20} mix by replacement of cement with 30% hypo sludge.

More important, that the concept of Green Building and sustainable development principles, which will modify the whole picture in favor of the environment. Advances in concrete research have demonstrated that it is possible to coordinate these two developments, thereby minimizing the need for vast additional cement production capacity and creating that balancing act of sustainable development on a global scale.

The concrete industry, which uses vast amounts of energy and natural resources and contributes to generation of CO_2, can improve its record with an increased reliance on recycled materials and in particular by replacing larges percentages of Portland cement by byproducts of industrial processes. Substitution of waste materials will conserve resources, and will avoid environmental and ecological damages. But let us now all work together to keep our planet livable.

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