

Effective use of Paper Sludge (Hypo Sludge) in Concrete

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Abstract— Paper making generally produces a large amount of solid waste. 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. This paper mill sludge consumes a large percentage of local landfill space for each and every year. 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, large quantity of national and international references are studied and based on these the state of art of the research and investigations on the production of low cost concrete by blending various ratios of cement with hypo sludge is presented in this paper.

Key words: Hypo Sludge, Pozzolanic Property, Supplementary Cementitious Materials

I. INTRODUCTION

Energy perform a important role in growth of developing countries like India. In the environment of low availability of nonrenewable energy resources coupled with the requirements of large quantities of energy for Building materials like cement, the importance of using industrial waste cannot be neglected. Industrial wastes produced per annum by chemical and agricultural process in India 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 after that the broken, low- quality paper fibers are separated out to become waste sludge. Paper sludge contains silica and magnesium like cement 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 raw material being used and end product being manufactured.[8]

A. Source of Hypo Sludge:

Hypo sludge is formed as waste by-product is purely a chemical wastes and do not contain any bio-degradable element. 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.[7]



Fig. 1: Hypo Sludge

II. LITERATURE REVIEW

Some information has been published on uses for hypo sludge. There is a lack of information on the engineering properties of the material.

In 2013, Jayraj et al done experimental investigation on strength of concrete and optimum percentage of the partial replacement by preparing a mix M20 grade was designed as per Indian Standard method and the same was used to prepare the test samples. In the test performed, the optimum compressive stress obtained by utilizing paper waste was at 30% replacement. The compared values of cost show gradual decrement in total cost of per cubic meter concrete. When government implement the projects for temporary shelters for who those affected by natural disaster, this material can be used for economic feasibility.[5]

In 2013, Jayesh kumar Pitroda et al focused on investigation of strength of concrete and optimum percentage of the partial replacement by replacing cement via 10%, 20%, 30%, and 40% 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.[2]

In 2013, Rushabh shah and J. Pitroda study the results of the cement mortar of mix proportion 1:3 in which cement is partially replaced with Hypo Sludge as 0%, 10%, 30% and 50% by weight of cement. Test results indicate the decreases in the strength properties of mortar with Hypo Sludge for strength at 7 & 28 days as partial replacement with the cement in the cement mortar 1:3. So it can be used in non-structural elements in the low range compressive strength where strength is not required and low cost temporary structure is prepared.[6]

In 2014, Ritesh Patil and M.Jamnu study the various mechanical properties of concrete containing hypo sludge. Hypo sludge was used as a replacement to cement. Replacement percentages used during the present study were 10%, 15%, 20%, 25%. Compressive strength of cubes were found on 3days, 7days, and 28days. The 28th day flexural strength and split tensile strength of the specimens was found on the respectively beams and cylinders. It is found that replacement of hypo sludge have beneficial effects on the mechanical properties of concrete.[9]

In 2014, R. Balamurugan and R. Karthickraja produce low cost concrete by blending various ratios of cement with hypo sludge. 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.

In 2014, Abdullah Shahbaz Khan et al present dissertation work is directed towards developing low cost concrete from paper industry waste. Dissertation work is carried out with M20 & M30 grade concrete with W/c ratio

of 0.55 & 0.45 respectively as a control specimen and hypo sludge is replaced in different percentages such as 10%, 20%, and 30% by weight of cement. Test was conducted to study the mechanical properties of concrete, such as compressive strength, split tensile strength and flexural strength. The curing period should be 3, 7 and 28 days.[1]

III. MATERIALS AND PROPERTIES

A. Materials

- Hypo Sludge,
- Cement
- Coarse Aggregate
- Fine Aggregate
- Water

B. Properties of Hypo Sludge

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 SiO₂, Al₂O₃ and Fe₂O₃ 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. The following tables shows the hypo sludge chemical properties and comparison between cement and hypo sludge.[8]

Sr. 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 Ignescant	27.00
5	Acid Insoluble	11.1
6	Silica(Sio ₂)	9.0
7	R ₂ O ₃	3.6

Table 1: Properties of Raw Hypo Sludge

Sr. 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

Table 2: Comparison of Cement and Hypo Sludge

Following conclusion can be drawn from the results of chemical analyses of cement and hypo-sludge.[7]

- The Hypo sludge obtained is 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 most suitable.
- Hypo sludge is the very desirable material as a replacement of cement.

IV. MIX DESIGN AND EXPERIMENTAL STUDY

A. Mix Design

A mix M20 grade was designed by most of the researchers as per IS 10262:2009 and the same was used to prepare the test samples.

B. Experimental Study

The quantity of cement, fine and coarse aggregates, hypo sludge and water each batch of proportion is prepared as mentioned in mix design. Then the mixing process is carried out.

1) Workability of Fresh Concrete by Slump Test:

Slump test is used to determine the workability of fresh concrete. The apparatus used for doing slump test are Slump cone and tamping rod.



Fig. 2: Concrete Slump

2) Compressive Strength Test:

150 mm X 150mm X 150mm concrete cubes were casting using M20 grade concrete. Specimens with ordinary Portland cement (OPC) and OPC replaced with hypo sludge at 10%, 20% and 30% levels were cast. After 24 hours, the specimens were removed from the mould and subjected to water curing for 3,7 and 28 days. After curing, the specimens were tested for compressive strength using a compression testing machine of 2000 kN capacity.



Fig. 3: Compression Test

3) Split Tensile Strength Test:

Split tensile strength of concrete is usually found by testing plain concrete cylinders. Cylinders of size 150mm x 300 mm were casting using M20 grade concrete. Specimen with OPC and OPC replaced by hypo sludge at 10%, 20% and 30% replacement levels were cast. After 24 hours, the specimens were removed from the mould and subjected to water curing for 28 days. After curing, the specimens were tested.

V. RESULT AND DISCUSSIONS

A. Workability of Fresh Concrete:

According to the Abdulla Shahnaz et al the slump value decreases as the replacement of cement increases by hyposludge.[1] Jayeshkumar found that the slump value increases as the replacement of cement by hyposludge increases i.e. the workability of concrete increases. Mehtab Alam also suggest that as the replacement ratio increases the slump value decreases but after some limit the slump value increases.[] R. Balamguru also conclude that as replacement ratio increases the slump value decreases.[]

B. Mechanical Properties

1) Compressive Strength

Study by Abdullah Shahbaz khan et al shows the compressive strength of M20 grade concrete at 28 days for 10% and 20% replacement of Cement by Hyposludge is 34.79 and 29.18 MPa respectively which is greater than conventional concrete[1] also Jayeshkumar shows the comp.strength 29.63, 17.78 MPa [2]. Jayraj Vinod singh maximum comp. strength is at 10% replacement which is greater than conventional concrete [5].

2) Split Tensile Strength

According to Abdulla shahnaz the split tensile strength For M20 grade concrete with 10,20 and 30 percent replacement is 3.8, 2.93 and 2.55 respectively. Jayesh Kumar Shows that split Tensile strength was 3.26, 2.43, 1.72 and 1.28 for M25 concrete with replacement 10,20,30 and 40 percent respectively. R. Shrinivasan gives the result of split tensile as 1.56, 1.48, 1.42 and 1.39 for M20 concrete with 10, 20, 30 and 40 percent concrete respectively.

These results show that there is an increase in compressive strength, split tensile strength with 10%, 20% replacement of cement with hypo sludge and it decreases with 30% replacement.

3) Economic Feasibility:

Cost analysis is carried out for the optimum proportion of percentage of hypo sludge in concrete. The cost is compared to the conventional concrete.[7]

- 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

VI. CONCLUSIONS

The following observations are made regarding the resistance of partially replaced hypo sludge.

A. Workability:

As the percentage of hypo-sludge in the mix increases the slump decreases.

B. Compressive Strength

The compressive strength increases as the curing period increasing for M20 grade concrete, compressive strength of CVC and 20% are approximately same but it increase with 10% replacement and finally it starts decreasing in strength with 30% replacement.

C. Split Tensile Strength

It is observed that in split tensile strength of M20 grade concrete. The strength of concrete has increased with 10% replacement of hypo sludge with cement as compare to conventional concrete and with 20% replacement it is slightly more or we can say it as equivalent but with 30% its start decreasing in strength.

D. Flexural Strength

It is observed that in flexural strength of M20 grade concrete the strength of concrete has increased with 10% replacement of hypo sludge with cement as compare to conventional concrete and with 20% replacement it is slightly more or we can say it as equivalent but with 30% its start decreasing in strength.

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