

# Review study on: Comparative study of properties of concrete by replacement of Cement with hyposludge exposed to elevated temperature

Diptesh Thombare <sup>1</sup>, Rahul Patil<sup>2</sup>

<sup>1</sup>PG Student, K.E. Society's Rajarambapu Institute of technology, An Empowered Autonomous Institute, Affiliated to Shivaji University, Kolhapur

<sup>2</sup>Assistant Professor, K.E. Society's Rajarambapu Institute of technology, An Empowered Autonomous Institute, Affiliated to Shivaji University, Kolhapur

**Abstract**—One of the industrial sectors that is expanding globally is the paper industry. Paper mill waste creation is an inevitable problem. One problem that needs attention is the solid debris, or hyposludge, that is created during the paper coating process. It must be disposed of without endangering human health or the environment. However, the hyposludge problem is not as noticeable as the paper industry's waste-water crisis. When hyposludge is dumped straight into rivers, it fills up the riverbed, causes issues for arable land, and requires a lot of land to dispose of. Hyposludge, a solid waste product of the paper industry, must therefore be properly controlled. The negative impacts of hyposludge as a waste product and potential benefits are discussed in this research.

**Index Terms**—hyposludge, cement concrete, utilization construction industry.

## I. INTRODUCTION

For emerging nations like India to prosper, energy is essential. Along with the high energy requirements for building materials like cement and the limited supply of non-renewable energy supplies. We must discover substitute materials for concrete because the earth's surface is becoming less suitable for it. The primary issue pertaining to industrialization is the difficult task of disposing of industrial trash. One such type of industrial waste that comes from the paper industry is hypo-sludge. Since correct disposal of waste is crucial, it is possible to replace sludge with various types of cement. In this regard, using Hypo sludge is regarded as one of the sustainable methods. Low calcium, high calcium chloride, and a little amount of silica and magnesium-like cement are all present in

the Hypo sludge, which helps the concrete set.

One to three tons of earth resources, such as limestone, are needed to make one ton of ordinary Portland Cement production significantly contributes to carbon emissions, as the manufacturing of one ton of ordinary Portland cement releases approximately an equal amount of carbon dioxide into the atmosphere. The ecology is silently killed by carbon dioxide emissions in a variety of ways. In this context, it is necessary to look for a less expensive alternative to OPC. The study focuses on testing concrete's strength at different temperatures, determining the ideal percentage of cement that can be partially replaced by anaerobic sludge, and determining the strength of mixed materials. It also determines the percentage of cost savings from replacement. There is no doubt that this project will significantly reduce environmental production. We engineers must come up with a workable remedy because of the numerous negative effects of cement manufacture and the ensuing environmental damage. Consequently, hypo sludge, a waste product of the paper industry, is being introduced as a new building material to partially replace cement.

### 1.1 HYPOSLUDGE

Another name for hypo sludge is paper industry waste. In general, a lot of solid waste is produced throughout the papermaking process. Every year, a significant portion of the local landfill space is occupied by this paper mill muck. It is crucial to turn these industrial wastes into viable building materials in order to lessen the pollution and disposal issues they cause. Different mills produce different amounts of sludge. By partially

substituting hypo sludge for cement, we can reduce waste. created by the mills that generate paper. Concrete would be stronger thanks to the magnesium and silica particles found in hypo sludge. Hypo sludge is a relatively new material for cementation. Originally, it was made as artificial pozzolana, which was a waste product of the paper industry's several processes. In general, the paper industry generates a lot of solid waste. The number of times that paper fibers can be recycled is restricted. Three different forms of sludge are produced by the paper making process: lime sludge, ETP sludge, and de-linking sludge. We partially substituted lime sludge for cement in our project. An average of forty dry tons of sludge are produced daily by each Indian paper mill. The specific gravity of the average hypo sludge is 2.80, however when the silica content is low, it is very little higher. The specific gravity of cement, which is 3.15, can be compared to this figure.1



Figure 1 Hyposludge

**CHEMICAL PROPERTIES OF HYPOSLUDGE**

Understanding the chemical properties of Hypo Sludge is essential for evaluating its suitability and performance in various applications, especially in concrete production. Some chemical properties are shown in table 1.

Table 1 chemical properties of hyposludge

SR. No.	Particular	Proportion
1	Silicon dioxide (SiO <sub>2</sub> )	9.27%
2	Aluminum oxide (Al <sub>2</sub> O <sub>3</sub> )	1.45%
3	Iron oxide (Fe <sub>2</sub> O <sub>3</sub> )	1.68%
4	Calcium Oxide (CaO)	29.83%
5	Magnesium Oxide (MgO)	4.28%
6	Loss on Ignition	49.24%

**II LITERATURE REVIEW**

Research articles published by various authors in different papers have been studied and are summarized in the following section

Albinas Gailius et.al (2003) investigated workability and strength of concrete made with different proportions of waste paper sludge ash (WSA) and ground granulated blast furnace slag (GGBS) as binder, at two w/b ratios: 0.5 and 0.4. The rate of development of strength of concrete made with WSA-GGBS binder achieved 1-day strength of about 2-6 % of its 28- day strength, while the 7-day strength was in the range 53-64 % of the 28-day strength. (1)

Sajad Ahmad et.al (2013) replaced as 5%, 10%, 15% and 20% of cement in concrete for M- 25 mix by Waste Paper Sludge Ash and tested. Use of waste paper sludge ash in concrete will preserve natural resources that are used for cement manufacture and thus make concrete construction industry sustainable and waste paper sludge can be used as fuel befousing its ash in concrete for partial cement replacement and also the disposal problem for paper industries for this waste material is fully solved. (2)

According to Balamurugan R et al. (2014), cement was partially replaced with hypo sludge at varying proportions of 0%, 5%, 10%, 15%, and 20%, and the compressive strength was evaluated after 28 days of curing. The study revealed that compressive strength improved with hypo sludge replacement up to 10%, making it a viable substitute for cement at this level. Incorporating hypo sludge in concrete can lower construction costs and promote sustainable practices by reusing industrial waste. However, due to its lower silica content compared to cement, the addition of silica can significantly enhance the overall strength of the concrete. This type of concrete will be used for road works effectively with less consumption of cement. (3)

J. Bai et al. (2003) conducted a study to examine the compressive strength and hydration behavior of blended pastes made from wastepaper sludge ash (WSA) and ground granulated blast furnace slag (GGBS), using a water-to-binder ratio of 0.5. The optimum blend composition to give maximum strength was 50% WSA–50% GGBS, and after 90 days, pastes manufactured from this blend exhibit compressive strengths close to 50% of those from an equivalent Portland cement paste.(4)

Sumit A Balwaik et al. (2010) explored the potential

of incorporating paper mill sludge into concrete as a sustainable alternative to its conventional disposal in landfills. Replacing cement with waste paper sludge in proportions ranging from 5% to 20% by weight was tested for M20 and M30 grade concrete mixes. The slump value improved with up to 5% replacement, indicating enhanced workability. Mechanical properties such as compressive strength, split tensile strength, and flexural strength showed improvement up to a 10% substitution level. However, an increase in paper pulp content led to higher water absorption in the concrete, likely due to its participation in the hydration process. To address this, additional water was required to ensure complete cement hydration, a common approach in such scenarios. However, higher water content decreases the strength of concrete. (5)

Bashar S. Mohammed et al. (2011) concluded that an increase in paper mill residue and fly ash content in concrete mixtures raises the water demand to maintain a consistent slump, thereby reducing the workability of the fresh mix. However, this reduction in workability can be effectively addressed by incorporating an appropriate dosage of superplasticizer. The Class F fly ash decreased the workability of concrete due to its high percentage of fly ash replacement in mixture proportion and high carbon content which increases the water demand. (6) Dharani N et al. (2013) investigated the use of hypo sludge as a partial replacement for cement in concrete at varying levels of 10%, 20%, 30%, 40%, and 50%. Alongside each replacement level, Recron 3s fibers were added at 0.2%, 0.3%, and 0.4% to evaluate their effect on the mechanical properties of the concrete. The study identified 30% hypo sludge replacement as the most effective when fibers were not included. When Recron 3s fibers were introduced, compressive and split tensile strengths showed a decreasing trend with higher fiber content, whereas flexural strength improved as the fiber percentage increased. When hypo sludge and Recron 3s fiber added, the optimum dosage of Hypo sludge was 20% and optimum Fiber content was 0.4%. (7)

Gabriele Fava et al. (2011) concluded that incorporating paper mill sludge ash (PA) as a partial replacement for Portland cement, up to a 10% level, can enhance the mechanical properties of mortar. However, due to its fine particle size and high-water absorption capacity, a greater amount of water was necessary to maintain workability. It was concluded

that the use of PA should not be higher than 10% by weight of the cement replaced, unless mortar mixtures are judiciously proportioned. (8)

Ishimoto H. et al. (2000) observed that increased paper recycling efforts have led to a continuous rise in the generation of papermaking sludge, with annual production in Japan exceeding 3 million tons. The Nippon Telegraph and Telephone Corporation successfully developed a porous material with a high cation exchange capacity by treating ash from incinerated papermaking sludge in an alkaline solution. The application of the new material could be to environmental conservation, such as improvement of water quality and admixture in concrete. (9)

Jan-Erik Nylunda et al. (2012) explored how the term 'sustainability' is interpreted differently depending on the stakeholder. Their study focused on the Brazilian pulp producer Veracel Cellulose and other leading cellulose pulp companies in South America, highlighting the gap between corporate and local community perspectives on sustainability. The research emphasized the importance of aligning these viewpoints to achieve genuine, long-term sustainable development. of company operations, sustainable business development of the pulp and paper industry should include local livelihood perspectives to a greater extent than at present. (10)

### III RESEARCH GAP

Following are the research gaps identified through the rigorous literature study.

As indicated in the literature review, there has been much research on the use of hyposludge as a partial replacement for cement in various grades of concrete. However, there is still a chance to analyse the behaviour of hyposludge concrete when subjected to elevated temperatures.

### IV. CONCLUSION

The following conclusions were made from the above literature review.

1. Incorporating hypo sludge into concrete can reduce waste disposal expenses and contribute to the production of environmentally friendly concrete for construction purposes.

2. Hypo Sludge can be used to prepared low-cost temporary structure.
3. Hypo sludge can be utilized as a construction material in applications where high structural strength is not a primary requirement.
4. This cost-effective concrete helps minimize environmental impact by reducing both industrial waste and the residual emissions associated with cement production.
5. Hypo sludge, a waste byproduct from the paper industry, shows promise as an innovative supplementary cementitious material in construction. However, its utilization requires careful and informed decision-making by engineers.

#### REFERENCES

- [1] Albinas Gailius a & Živilė Laurikietytė (2003), “Waste Paper Sludge Ash and Ground Granulated Blast Furnace Slag as Binder in Concrete”, *Journal of Civil Engineering and Management*, 9:3, 198-202.
- [2] Ahmad Sajad, Iqbal Malik M., Wani Muzaffar Bashir, Ahmad Rafiq (2013), “Study of Concrete Involving Use of Waste Paper Sludge Ash as Partial Replacement of Cement”, *IOSR Journal of Engineering (IOSRJEN)* e-ISSN: 2250-3021, p-ISSN: 2278-8719 Vol. 3, Issue 11 (November), ||V3|| PP 06-15.
- [3] Ahmad Ruslan Mohd Ridzuan, Mohd Azrizal Fauzi, Ezliana Ghazali, Mohd Fadzil Arshad and Mohd Afiq Mohd Fauzi (2011) “Strength Assessment of Controlled Low Strength Materials (CLSM) Utilizing Recycled Concrete Aggregate and Waste Paper Sludge Ash”, *IEEE Colloquium on Humanities, Science and Engineering Research (CHUSER 2011)*, Dec 5-6, Penang, PP-208-211.
- [4] Bai J., Chaipanich A., Kinuthia J.M., O’Farrell M., Sabir B.B., Wild S., Lewis M.H. (2003), “Compressive strength and hydration of wastepaper sludge ash–ground granulated blastfurnace slag blended pastes”, *Cement and Concrete Research* 33,1189–1202.
- [5] Balwaik Sumit A, Raut S P (2010), “Utilization of Waste Paper Pulp by Partial Replacement of Cement in Concrete”, *International Journal of Engineering Research and Applications (IJERA)* ISSN: 2248-9622, Vol. 1, Issue 2, pp.300-309.
- [6] Balamurugan R and Karthickraja R. An Experimental Investigation of Partial Replacement of Cement by Industrial Waste (Hypo Sludge). *Int. Journal of Engineering Research and Applications* 2014; 4 (1): 430- 435.
- [7] Dharani. N, Ashwini. A, Pavitha. G, Prince Arulraj. G (2013), “Experimental Investigation on Mechanical Properties of Recron 3S Fiber Reinforced Hyposludge Concrete”, *International Journal of Civil Engineering and Technology (IJCIET)* ISSN 0976 – 6308 (Print) ISSN 0976 – 6316(Online) Volume 4, Issue 1, January-February, pp. 182-189 © IAEME
- [8] Fava Gabriele, Letizia Ruello Maria, Corinaldesi Valeria (2011), “Paper Mill Sludge Ash as Supplementary Cementitious Material”, *Journal of Materials in Civil Engineering*, Vol. 23, No. 6, June, pp. 772-776.
- [9] Ishimoto H., Origuchi T., Yasuda M., (2000), “Use of paper making sludge as new material”, *Journal Material Civil Engineering* 12(1), pp.310-313.
- [10] Jan-Erik Nylunda & Markus Krögerab (2012), “Cleavage in the understanding of sustainability: Sustainable pulp industry versus sustained local livelihood”, pages 229-240, Volume 27, Issue 2, Taylor & Francis online.