Effect of Paper Sludge Ash on Properties of Concrete

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***Abstract* - Cement manufacturing industry is one of the carbon dioxides emitting sources beside deforestation and burning. cement is widely used material in the global construction industry. The cement is primarily used as the key binder and significant environmental and economic challenges. The global cement industry emitter of carbon dioxide around 7% (approximately). The cement industry is directly effecting and constantly depleting natural resources. There we need to find and develop the alternative binder to make concrete industry ecofriendly and long-lasting. This study looks at using waste paper sludge ash to replace some cement in concrete. In these study waste paper sludge ash was partially replaced with cement in the proportion of 5%, 10%, 15%, 20% and 25% in a concrete mix and tested for its compressive strength for 7 days, 14 days and 28 days and compared with conventional concrete. The result obtained that the waste paper sludge can be used as cement replacement further. Waste paper sludge has very high calorific value and could be used as fuel before using its ash as partial cement replacement.**

***Keywords:* - Compressive strength, Durability, Wastepaper Sludge Ash Concrete, Workability.**

I.INTRODUCTION

To enhance the economic viability and environmental sustainability of the concrete industry. The use of waste materials play very important role in place of natural resources is one of the best method waste from the paper mills causes serious cost and environmental issues for the industry. Huge quantities of paper sludge are generated across the world. In India it produces nearly 0.7% of city waste (Sajad Ahmad, M. Iqbal Malik, Muzaffar Bashir Wani, Rafiq Ahmad). India produces over 0.75 to 1.3 million tons of wastepaper sludge annually. The paper sludge as a byproduct with high moisture content, complex organic composition, and disposal challenges for the paperboard industry. The paper sludge material is produced as a byproduct during the recycling of paper. It is commonly disposed of by using it as fertilizer, burning it form ash and sending it to landfill. The use of paper sludge for land disposal is limited and managed. It contains cellulose fibers and fillers such as calcium carbonate and clay, along with chemicals like lignin, hemicellulose, residual bleaching agents, and trace amounts of alum, with about 40% moisture it is sticky and difficult to handle. It's energy content fuel in cement manufacturing (Dunster, A.M., MinRes Case Study, Building Research Establishment, Garston, (2007).

After burning paper sludge at around 700° to 800° , the ash formed contains silica, alumina and lime, which are important for cement. The ash can be used in cement mixture and production (F. Delarama, Y. Mohammadi, M. R. Adlparvarc 2021). This research studies the effect of replacing cement with 5% to 25% paper. sludge ash in concrete. It helps in reducing waste and may improve strength because of the presence of silica.

Industrial by-products and waste materials such as fly ash, silica fume, ground granulated blast furnace slag (GGBS), and rice husk ash have been successfully used as supplementary cementitious materials. These materials show pozzolanic or cementitious properties that contribute to the strength and durability of concrete. Among these wastes, Paper Sludge Ash (PSA), a by-product of the paper manufacturing and recycling industry, has recently gained attention due to its potential to partially replace cement (Mozaffari, E., Kinuthia, JM., Bai 2020)

Paper sludge, generated during the pulping and de-inking processes, consists mainly of calcium carbonate, fibers, fillers, and inorganic compounds such as kaolin clay, titanium dioxide, and residual ink particles. When incinerated, it produces Paper Sludge Ash (PSA). PSA often contains silica, alumina, lime,

and trace compounds that may participate in hydration and pozzolanic reactions.

II.MATERIALS USE

2.1 Cement and Aggregates: -
Ordinary Portland cement of 53 grade IS 12269 (1987) was used throughout the work. Fine aggregate use throughout the work as per IS 383 (1970) with specific gravity of 2.6. coarse aggregates used consisted of machine crushed stone angular in shape passing through 20 mm IS sieve and retained on 4.75 mm IS sieve with specific gravity of 2.7.

2.2 Wastepaper sludge ash: -
Wastepaper sludge was obtained from Datala paper mill wastepaper corporation, Malkapur Maharashtra, India. It was then sun dried and incinerated so as to convert it into ash. The ash was sieved through 90 micron (90µm) Indian Standard sieve. The specific gravity of wastepaper sludge ash was found to be 2.6. Chemical composition of paper sludge ash is presented in wastepaper sludge ash, sieved paper sludge ash and mixing of paper sludge ash with cement.

Fig.1: Waste Paper Sludge Ash

III.EXPERIMENTAL INVESTIGATION

I. Mix Proportion: -
The concrete mix design was proposed by using IS 10262. The grade of concrete used was M-25 with water to cement ratio of 0.45. The mixture proportions used in laboratory for experimentation are shown in TABLE 1.

Table 1: Mix Proportions

Paper Sludge Ash %	w/c ratio	Water (Kg/m3)	Cement (Kg/m3)	Fine Aggregate (Kg/m3)	PSA (kg/ m2)	Coarse Aggregate (Kg/m3)
0	0.50	197	394	865	0	1075
5	0.50	197	374.3	865	19.7	1075
10	0.50	197	354.6	865	39.4	1075
15	0.50	197	334.9	865	59.1	1075
20	0.50	197	315.2	865	78.8	1075
25	0.50	197	295.5	865	98.5	1075

3.2 Test on Cement: -
Fineness test was performed on cement using sieve analysis as per IS 4031 (Part 1) to determine the fineness of cement. Specific gravity test was carried out using a Le Chatelier flask as per IS 4031 (Part 11). Initial and final setting time and consistency of cement were tested using the Vicat apparatus as per IS 4031 (Part 5) and IS 4031 (Part 4) to determine the standard water–cement ratio.

Tests on hardened concrete: -
From each concrete mixture, cubes of size 150mm x 150mm x 150mm have been cast for the determination of compressive strength and splitting tensile strength respectively. The concrete specimens were cured under normal conditions (room temperature of about 27 ± 2 °C) as per IS 516-1959 and were tested at 7 days, 14 days and 28days for determining compressive strength as per IS 516-1959.

Fig.2: Compressive strength test of cube using CTM

Table 2: Compressive Strength Test results for cube specimens of size 150mm x 150mm x 150mm.

Sr. no.	Percentage	Avg. Compressive Strength @7 days(N/mm2)	Avg. Compressive Strength @14 days(N/mm2)	Avg. Compressive Strength @28 days(N/mm2)
1	0	16.8	22.5	25.8
2	5	17.5	23.4	26.8
3	10	18.0	24.0	27.5
4	15	16.7	22.6	25.8
5	20	15.5	21.0	23.9
6	25	14.0	19.0	21.5

IV.RESULT AND DISCUSSION

The compressive strength tests are presented in Table 3 respectively. Compressive strength tests were carried out on 7 days, 14 days and 28 days. An increase in compressive strength was observed up to 10% replacement of cement by wastepaper sludge ash and there after decreasing. The maximum compressive strength measured was more than that of reference mix at 28 days corresponding to concrete mix containing 0% wastepaper sludge ash in place of cement. Compressive strength for concrete mix with 5%, 10%, 15%, 20% and 25% wastepaper sludge ash content was found to be less than that of reference mix.

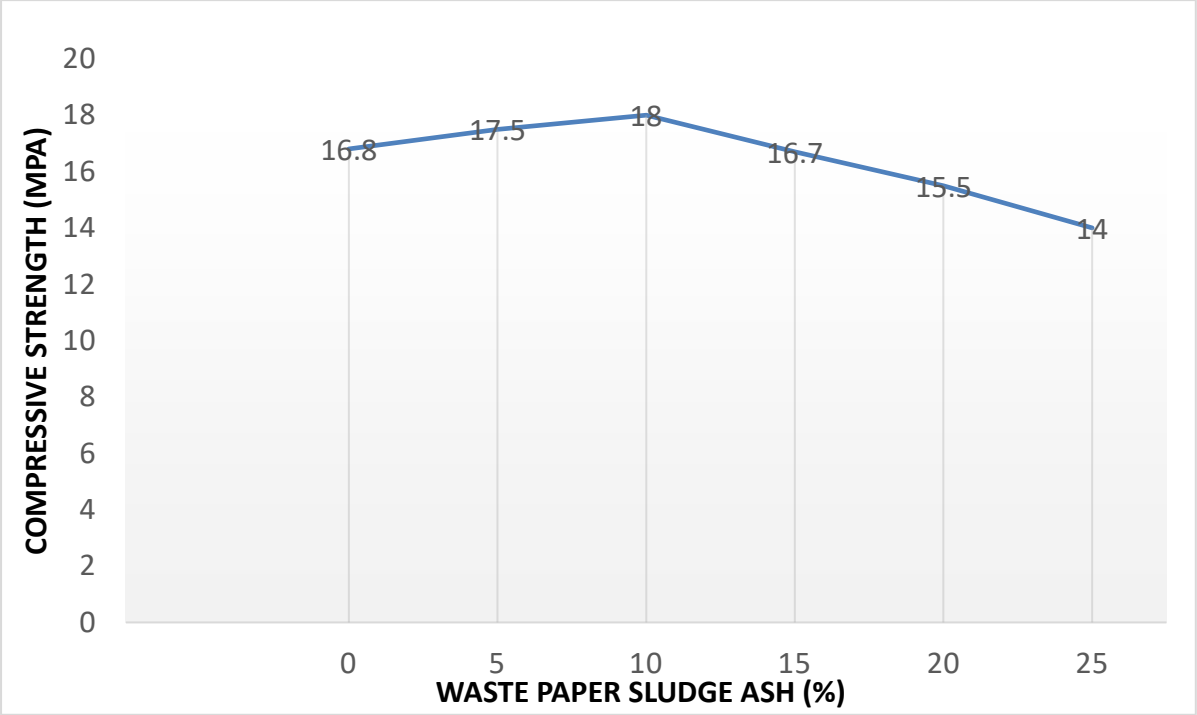

Fig.3: Variation of Compressive Strength @ 7days

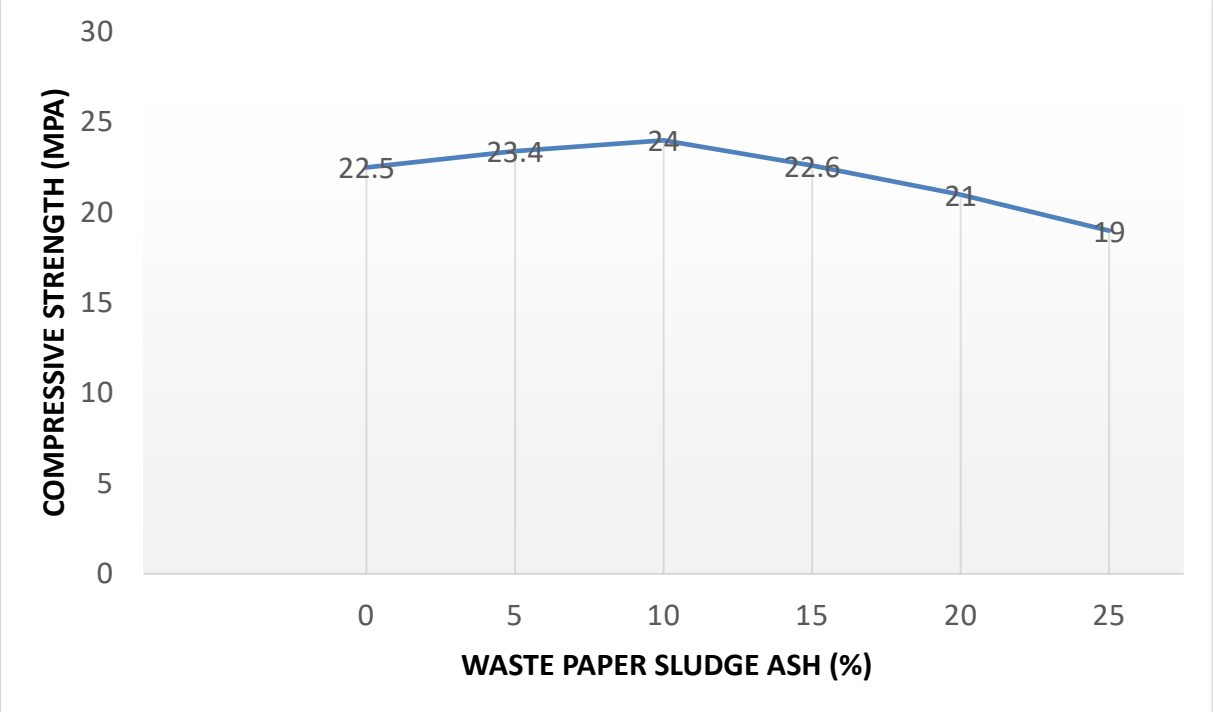

Fig.4: Variation of Compressive Strength @ 14days

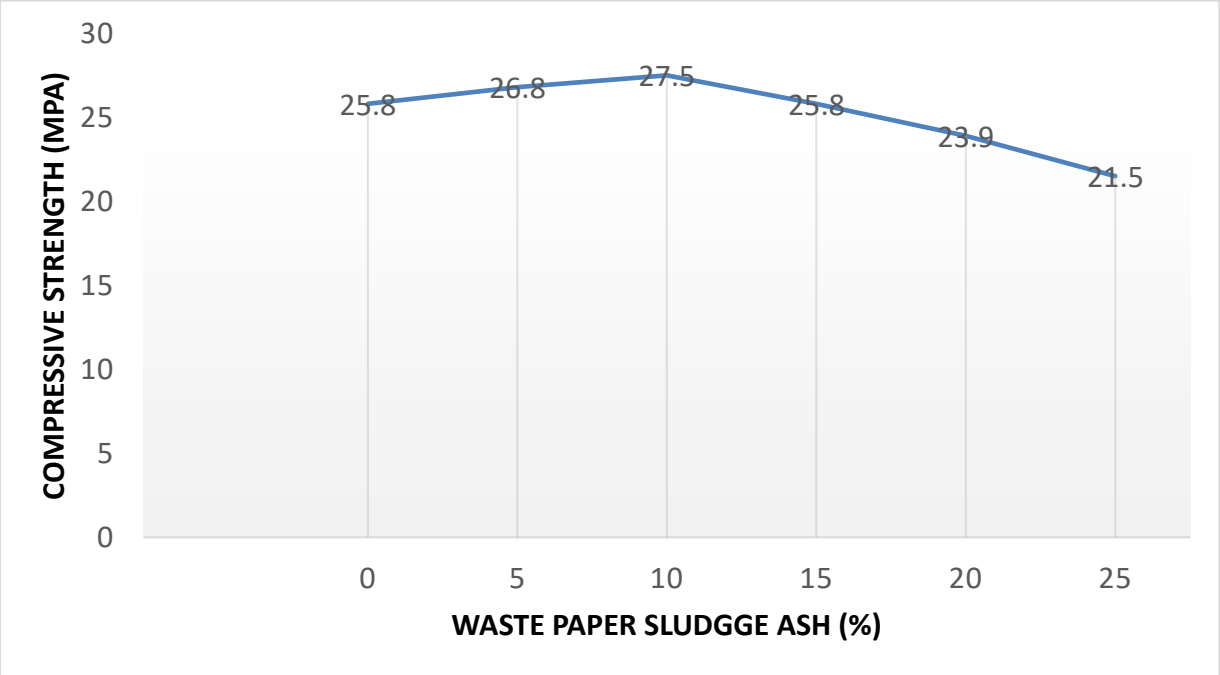

Fig.5: Variation of Compressive Strength @ 28days

V.CONCLUSION

Based on results obtained, following conclusions can be drawn

1. The experimental results indicate that 10% replacement of cement by wastepaper sludge ash provides the optimum compressive strength at all curing periods. The strength increases progressively from approximately 18 MPa at 7 days to 24 MPa at 14 days and 27.5 MPa at 28 days. Therefore, it can be concluded that 10% replacement level is ideal, as it enhances the strength characteristics of concrete, while higher replacement percentages lead to a reduction in strength.
2. With increase in wastepaper sludge ash content, percentage of compressive increases.
3. Using wastepaper sludge ash in concrete helps

save natural resources used in cement production. It makes the construction industry more sustainable.

4. Wastepaper sludge can also be used as fuel before converting it into ash.
5. Using this ash in concrete helps reduce waste disposal problems for paper industries.
6. The use of wastepaper sludge ash in concrete helps to solve disposal problems of this waste material. It also reduces harmful emissions from the cement manufacturing industry, making it more environmentally friendly. It promotes the development of greener and sustainable concrete.
7. Workability of concrete mix decreases with increase in wastepaper sludge ash content.
8. The use of wastepaper sludge ash in concrete can be economical, as it is a non-useful waste material and is available at low or no cost.

REFERENCES

[1] A S Rossomagina, D V Saulin, and I S Puzanov. (2002). Prevention of Alkali-Silica Reaction in Paper Sludge Ash & Glass Aggregate Concrete.Perm State Technical University, Russia. 102 (1), 2. Shayan and A. Xu. (Jan.2009). Value added utilization of wastepaper in concrete. Cement and Concrete Research. 44 (1), 81-89.

[2] B.S. Mohammed, O.C. Fang. (2011). Mechanical and durability properties of concretes containing papermill residuals and fly ash. Construction and Building Materials. 25 (1), 717–725.

[3] T.R. Naik. (July 2005). Concrete with paper industry: mixture. ACI Materials Journal. 102 (4), 237-243.

[4] T.R. Naik, Y. Chun, and R.N. Kraus. (2003). Use of residual solids from pulp and paper mills for enhancing strength and durability of ready-mixed concrete. US Dept. of Energy. DE-FC07 (00ID13867), 1-40.

[5] R. Srinivasan, K. Sathiya, and M. Palanisamy. (2010). Experimental investigation in developing low-cost concrete from paper industry waste. The Bulletin of the Polytechnic Institute of Jassy, Construction Architecture Section (Romania). 111 (3), 34-35.

[6] R.S. Gallardo, Mary Ann Q Adajar (December 2006). Structural performance of concrete with paper sludge as fine aggregates partial replacement enhanced with admixtures. In: Symposium on Infrastructure Development and the Environment, December 2006, University of the Philippines. p.p. 1-60

[7] IS (Indian Standard) (1959) IS 1199-1959: Methods of Sampling and Analysis of Concrete, Bureau of Indian Standards, New Delhi

[8] IS (Indian Standard) (1959) IS 516-1959: Methods of Tests for Strength of Concrete, Bureau of Indian Standards, New Delhi

[9] Pera, J. and Amrouz, A. (1998). Development of highly reactive metakaolin from paper sludge. Advanced Cement Based Materials. 7 (1), 49-56.

[10] Mavroulidou, M., and Shah, S., "Alkali-activated slag concrete with paper industry waste." Waste Management & Research, Vol. 39, No. 3, (2021), org/10.1177/0734242X20983890.

[11] Mavroulidou, M., and Awoliyi, S., "A study on the potential use of paper sludge ash in concrete with glass aggregate." Waste Management & Research, Vol. 36, No. 11, (2018), 1061-1065, DOI: org/10.1177/0734242X18801196.

[12] Dunster, A.M., "Paper sludge and paper sludge ash in Portland cement manufacture". MinRes Case Study, Building Research Establishment, Garston, (2007).

[13] Pera, J., and Amrouz A. "Development of highly reactive metakaolin from paper sludge." Advanced Cement Based Materials, Vol. 7, No. 2, (1998), 49-56, DOI: org/10.1016/S1065 7355(97)00016-3.

[14] Mozaffari, E., Kinuthia, JM., Bai, J., and Wild, S., "An investigation into the strength development of wastepaper sludge ash blended with ground granulated blastfurnace slag." Cement and Concrete Research, Vol. 39, No. 10, (2009), 942-949, DOI: org/10.1016/j.cemconres.2009.07.001.