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Application of Paper Waste in Cement Concrete

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ABSTRACT
India is facing a serious challenge in disposing the waste in landfills throughout the country. The landfill disposal is resulting in high disposal costs and potential environmental problems. If current trend continues, waste production will grow by 5% each year, which will ultimately result in saturated capacity of landfills by 2020. This paper reports on the results of an investigation of utilization of paper waste as additional material in concrete mixes to be used for housing projects, for which it must be assured that the resulting concrete has the proper mechanical strength. Concrete mixes containing various contents of the waste were prepared and basic characteristics such as compressive strength and water absorption were determined and compared with a control mix. Four concrete mixes with 0%, 10%, 15% and 20% of paper waste as an additional material to the concrete were prepared for M-25 concrete.

Keywords **-** Compressive strength, Density, Water Absorption, Slump Test, Concrete mix, Paper Waste.

I. INTRODUCTION:

This research is aimed to study the effect of paper waste on the strength of concrete and to develop mixture proportions for concrete containing paper waste. Paper waste has been used as building material for decades, especially in cementation matrices and since then a lot of research has been done to develop the mechanical properties of the composite like compressive, tensile and flexural strength. Most of the published works on recycling of papers are from paper mill (Bai et al., 2003; Chin et al., 1998; Chun et al., 2006; Gallardo, 2006; Kraus, 2003; Naik et al., 2004), or from manufacture cement board (Fuwape et al., 2007; Okino, 2000). Use of Paper waste in structural concrete could become an economical and profitable substitute to landfills, incinerator, or other use options. The research on use of paper sludge can be further carried out in concrete manufacturing as a new recycled material. The use of paper-mill pulp in concrete formulations was investigated as an alternative to landfill disposal.

India is facing a serious challenge in disposing waste in many landfills throughout the country. The landfill situation is resulting in high disposal costs and potential environmental problems. If current trend continues, with waste production projected to grow by 5% each year, landfills would be at full capacity by 2020.

The objectives of the study are:-

- Investigation of utilization of paper waste as additional material in concrete mixes to be used for various construction projects, ensuring that the resulting concrete has proper compressive strength.
- To prepare mixes containing various proportions of the paper waste.
- To determine basic characteristics of the concrete such as compressive strength, density, water absorption and slump value.
- Comparison of results of various characteristics with control mix.
- To minimize the cost of production of concrete by adding paper waste with concrete mix.

II. CEMENT AND COARSE AGGREGATES:

Ordinary Portland cement (Grade-43) meeting the requirement of IS -10262:2009 was used in this research. River sand and crushed granite with 5 mm and 20 mm maximum size respectively were used as fine and coarse aggregate in this research. Physical properties of sand and gravel are as per IS code. The sand and gravel met the requirements of IS Code.

PAPER WASTE:

The paper waste used in this study was collected from Security Paper Mill Hoshangabad, MP, India, which was dried in sunlight and then pulverized. SEM images below for paper pulp clearly indicate the presence of irregular pores and fibrous nature. The paper pulp holds the moisture in these pores. Fibrous nature gives very high energy absorbing ability and hence the high compressive strength.

Dried paper waste was soaked in water for 24 hrs and was agitated by mechanical means to attain consistency.

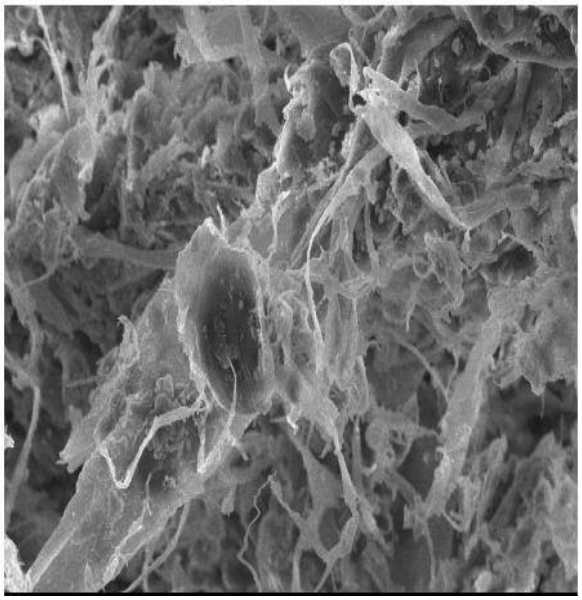


Figure.1 SEM monograph of virgin paper pulp sample "Balwaik Sumit A, Raut S P", (2013)

Dry mix of concrete was prepared by mixing all the ingredients in a mixer. The mix proportions for all mixes were based on weight proportions of M-25 (cement: sand: gravel) concrete. The water to cement ratio for the mixes containing the paper waste was based on preliminary testing to obtain a workable mix with enough water because of high water absorption of the paper waste.

The quantity of paper waste was increased in four trials as T-1, T-2, T-3 & T-4 Corresponding to 0%, 10%, 15% & 20% increment of paper waste. The properties of freshly mixed concrete were determined and test specimens were cast for the evaluation of strength of concrete.

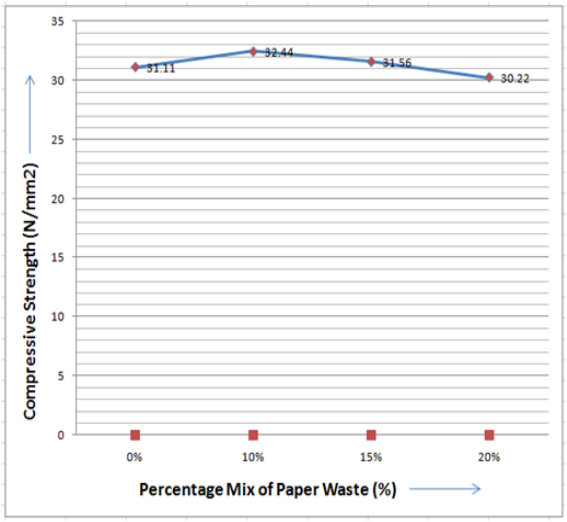
For each percentage increment of paper waste, three cube specimens wear tested for compressive strength and water absorption each at 7days and 28 days of curing period. A total of 24 specimens we made for the experimentation of this study.

III. COMPRESSIVE STRENGTH

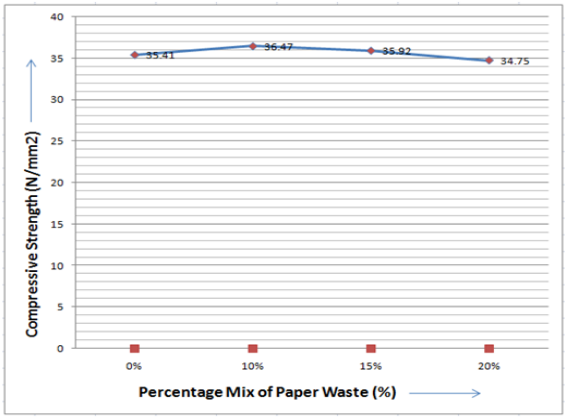
Compressive strength increases initially on addition of the paper waste, but it is decreased significantly on further addition of the paper waste. As it can be seen from the graph 1, at 7 days, compressive strength increases from 31.33 N/mm^2 to 32.44 N/mm^2 on 10% addition of waste while it decreased to 30.22 N/mm^2 on further 10% addition. A similar trend was observed in compressive strength for 28 days (graph 2).The results of compressive strength of different trials are summarized in table 1.

Table 1 Compressive Strength for Different Proportions of Paper Waste

Trial	Compressive Strength After 7 Days (N/mm^2)			Compressive Strength After 28 Days (N/mm^2)		
T-1 (0%)	27.11	35.56	30.67	36.89	34.67	34.67
	31.11			35.41		
T-2 (10%)	33.33	30.22	33.78	37.98	35.76	35.67
	32.44			36.47		
T-3 (15%)	30.67	33.33	30.67	37.89	39.98	34.88
	31.56			35.92		
T-4 (20%)	29.33	31.56	29.78	34.89	33.67	35.68
	30.22			34.75		



Graph 1: Variation in Compressive Strength of Concrete with Different Proportions of Paper Waste at 7 days.



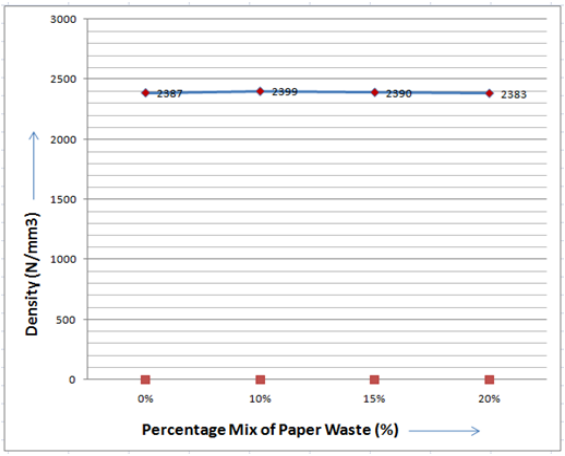
Graph 2: Variation in Compressive Strength of Concrete with Different Proportions of Paper Waste at 28 days.

IV. DENSITY

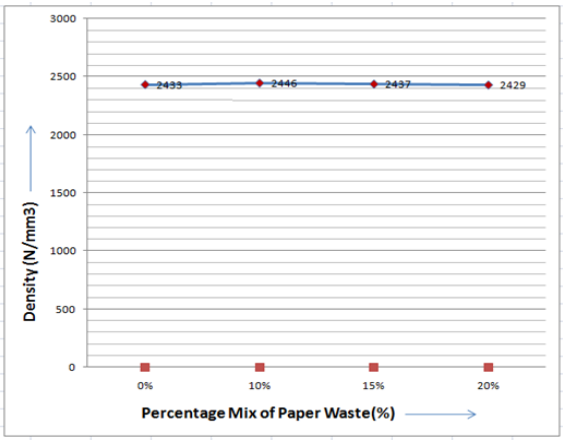
Density increases initially on addition of the paper waste, but it is decreased significantly on further addition of paper waste. As it can be seen from the graph 3 at 7 days, density increase from 2387 N/mm^3 to 2399 N/mm^3 on 10% addition of waste while it decreased to 2390 N/mm^3 to 2383N/mm^3 on further incremental addition 5% addition. A similar trend was observed in compressive strength after 28 days curing period (graph 4). The results of density of different trials are summarized table 2.

Table 2 Density for Different Proportions of Paper Waste

Trial	Density After 7 Days (N/mm^3)	Density After 28 Days (N/mm^3)
T-1 (0%)	2387	2433
T-2 (10%)	2399	2446
T-3 (15%)	2390	2437
T-4 (20%)	2383	2429



Graph 3: Variation in Density of Concrete with Different Proportions of Paper Waste at 7 days.



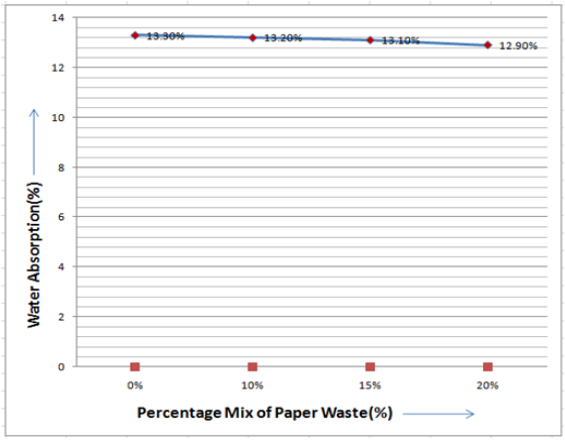
Graph 4: Variation in Density of Concrete with Different Proportions of Paper Waste at 28 days.

V. WATER ABSORPTION

Graph 5 and table 3 shows that the water absorption of concrete decreases, as the amount of paper waste increase. The water absorption rates were between 13.34% – 12.93% after 28 days.

Table 3 Variation in Water Absorption with Different Proportions of Paper Waste

Trial	Water Absorption (%)
T-1 (0%)	13.3%
T-2 (10%)	13.2%
T-3 (15%)	13.1%
T-4 (20%)	12.9%



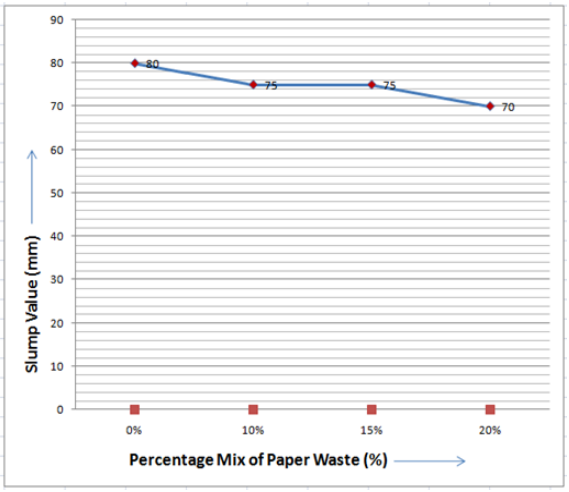
Graph 5: Variation in Water Absorption of Concrete with Different Proportions of Paper Waste at 28 days.

VI. WORKABILITY (SLUMP TEST)

Graph 6 and Table 4, shows that the slump value of concrete decreases, as the amount of paper waste is increase. The slump value was recorded between 80 mm – 70 mm.

Table 4 Variation in Slump Value with Different Proportions of Paper Waste

Trial	Slump Value (mm)
T-1 (0%)	80 mm
T-2 (10%)	75 mm
T-3 (15%)	75 mm
T-4 (20%)	70 mm



Graph 6: Variation in Slump Value of Concrete with Different Proportions of Paper Waste.

VII. COST ANALYSIS

The cost of concrete mix with 10%, 15% and 20% was estimated at Rs 4925/- , Rs 4890/- and Rs 4850/- respectively as against Rs 5000/- , the cost of M25 concrete without paper waste, the control mix.

VIII. CONCLUSION

Based on the results of study the following Conclusions are drawn.

- Concrete mixes containing 10% and 15% of paper waste, have shown an increase of 3.0% and 1.4% in compressive strength respectively when compared to control mix and there was a decrease of 1.9% on addition of 20% of paper waste.
- Density of concrete mix with 10% and 15% paper waste increased by 0.5% and 0.2% respectively compared to control mix but it decreased by 0.1% with 20% of paper waste.
- Slump value of concrete mix was decreased by 6.3% with 10% addition of paper waste while it remained constant at 6.3% decrease on addition of 15% of paper waste compared to control mix but it decreased by 12.5% with 20% addition of paper waste.
- Water absorption of concrete mix with 10%, 15% and 20% paper waste addition decreased continuously by 0.1%, 0.2% and 0.4% respectively compared to control mix.
- It can be concluded that an application of 10% of paper waste, to concrete mix may be conveniently allowed.
- The cost of production of concrete, when compared with control mix gets reduced by 1.5%, 2.2% and 3.0% with addition of 10%, 15% and 20% paper waste respectively.

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