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Durability Studies on Concrete with Hypo Sludge as Partial Replacement of Cement

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ABSTRACT
This paper summarizes the research work on the properties of **hypo sludge** when used as partial replacement for Ordinary Portland Cement (OPC) in concrete. OPC was replaced with **hypo sludge** by weight at 0%, 5%, 10%, 15%, 20% and 25%. 0% replacement served as the control. Compacting factor test was carried out on fresh concrete while Compressive Strength test was carried out on hardened 150mm concrete cubes after 7, 14 and 28 days curing in water. The results revealed that the Compacting factor decreased as the percentage replacement of OPC with **hypo sludge** increased. The compressive strength of the hardened concrete also decreased with increasing OPC replacement with **hypo sludge**. It is recommended that further studies be carried out to gather more facts about the suitability of partial replacement of OPC with **hypo sludge** in concrete.
Keywords: Concrete, hypo sludge, Compacting factor, Compressive strength

I. INTRODUCTION

Now a days there is a low availability of natural resources, Ordinary Portland Cement (OPC) are rapidly used throughout the world like in industries, residential buildings, power plants, transportation works, etc…So Production and utilization of concrete has rapidly increased. This results in increased consumption of natural aggregates. In olden days in mix of concrete they were use particular ingredients are cement, water, aggregates but now a days we use some waste materials that are locally available and at low cost to produce the durability strength of concrete as partial replacements of cement & aggregates. Industrial wastes are being produced per annum by chemical and agricultural process in India. These materials possess problems of disposal, health hazards and aesthetic problem. Concrete is a composite construction material composed of cement, fine & coarse aggregate, water and admixtures (if required). The objectives are to mix these materials traditionally to make concrete that is easy to Transport, place, compact, finish and to give a strong and durable product. The proportionate quantity of each material (i.e. cement, water and aggregates) affects the properties of hardened concrete. For 1 tons of OPC we use earth resources like limestone, etc& during manufacturing of OPC an equal amount of carbon-dioxide are released into the atmosphere which is harmful to the environment. Energy plays an important role in era of developing countries like India. 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. About 350 kg of sludge is produced for each tone of recycled paper. The main reason to take hypo sludge as a replacement material for cement is to it contains carbon oxides as well as equal % of OPC chemical composition and silicates are also present in these hypo sludge, its increases the setting time and strength of concrete. So it helps to reduce the environmental pollution.

II. MATERIALS AND METHODS

2.1. Materials

2.1.1. Hypo sludge

The production of Hypo sludge is estimated about 35% of the daily production in the paper industries. These wastes are used as an ingredient of cement manufacturing in wet process. But present days we use dry process for manufacturing of cement so hypo sludge are not useful for manufacturing of cement. The paper industries are dumped these waste nearby any pit or waste land. It leads to effects the environmental issues.

2.1.2. Coarse Aggregate

The coarse aggregate are granular materials obtained from rocks and crushed stones. Coarse aggregate form the main matrix of the concrete, in case of coarse aggregate maximum 20 mm coarse aggregate is suitable for concrete work.

But where there is no restriction 40 mm or large size may be permitted. Crushed granite aggregate conforming to IS: 383-1970 was used for the preparation of concrete. Coarse aggregate of size 20 mm having the specific gravity of 2.8.

2.1.3. Fine Aggregate

Fine aggregate are material passing through an IS sieve that is less than 4.75 mm gauge beyond which they are known as coarse aggregate. Fine aggregate form the filler matrix between the coarse aggregate. The most important function of the fine aggregate is to provide workability and uniformity in the mixture. The fine aggregate also helps the cement paste to hold the coarse aggregate particle in suspension.

2.1.4. Cement

Ordinary Portland cement is by far the most important type of cement. The OPC was classified into three Grades viz., 33 Grade, 43 Grade and 53 Grade depending upon the strength of the cement at 28 days when tested as per IS 4031-1988. If the 28 days strength is not less than 33 N/mm^2, it is called 33 grade cement, if the strength is not less than 43 N/mm^2, it is called 43 Grade cement, and if the strength is not less than 53 N/mm^2, it is called 53 Grade cement.

2.1.5. Water

The water used for the study was obtained from a free flowing stream. The water was clean and free from any visible impurities. It conformed to BS EN 1008:2002 requirements.

2.2. Batching and mixing of materials

Batching of materials was done by weight. The percentage replacements of Ordinary Portland cement (OPC) by **hypo sludge** were 0%, 5%, 10%, 15%, 20% and 25%. The 0% replacement was to serve as control for other samples.

2.3. Concrete Mix Design

The concrete used in this research work was made using Binder, Sand and Gravel. The concrete mix proportion was 1:2:4 by weight.

2.4. Casting of samples

Cubic specimens of concrete with size 150 x 150 x 150 mm were cast for determination of all measurements. Six mixes were prepared using different percentages of 0, 5, 10, 15, 20, 25 and 30 **hypo sludge**. The concrete was mixed, placed and compacted in three layers. The samples were de moulded after 24 hours and kept in a curing tank for 7, 14 and 28 days as required. The Compacting Factor apparatus was also used to determine the compacting factor values of the fresh concrete in accordance with BS 1881: Part 103 (1983).

2.5. Testing of samples

The compressive strength tests on the concrete cubes were carried out with the COMTEST Crushing Machine at The Sammya Construction Company, Osogbo, Nigeria. This was done in accordance with BS 1881: Part 116 (1983). The sample was weighed before being put in the compressive test machine. The machine automatically stops when failure occurs and then displays the failure load.

III. RESULTS AND DISCUSSIONS

3.1. Results of compacting factor test on fresh concrete samples

The results obtained from the compacting factor test on fresh concrete samples are given in Table 1.

Table 1: Compacting factor values of RHA concrete

Percentage replacement of hypo sludge (%)	Compacting Factor values
0	0.91
5	0.91
10	0.90
15	0.90
20	0.89
25	0.88

The table indicates that the compacting factor values reduce as the **hypo sludge** content increases. The compacting factor values reduced from 0.91 to 0.88 as the percentage **hypo sludge** replacement increased from 0% to 25%. These results indicate that the concrete becomes less workable (stiff) as the **hypo sludge** percentage increases meaning that more water is required to make the mixes more workable. The high demand for water as the **hypo sludge** content increases is due to increased amount of silica in the mixture. This is typical of pozzolan cement concrete as the silica-lime reaction requires more water in addition to water required during hydration of cement (Bui et al. 2005).

The results of the bulk densities show that the bulk density reduces as the percentage RHA increases. This could be attributed to the increase in voids in the concrete cubes as the percentage RHA

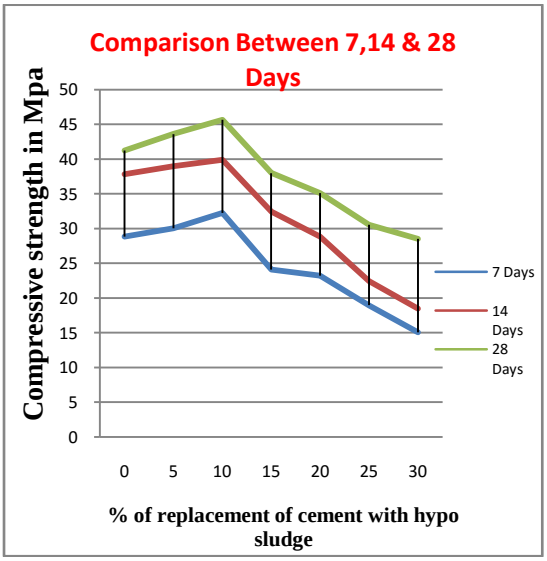
increases. However, the bulk densities increase as the number of days of curing increase as the concrete cubes become denser.

3.2. Results of Compressive Strength Tests on Concrete Cubes

The results of the compressive strength tests on concrete cubes are shown in Table 2.

Table 2: Compressive Strength of Concrete Cubes with various percentages of **hypo sludge**.

% Of Sample Replacement	7 Days	14 Days	28 Days
0%	27.83	36.83	40.23
5%	29.05	38.99	43.6
10%	31.28	39.91	45.65
15%	26.1	34.45	39.98
20%	23.24	32.25	37.11
25%	18.96	22.47	35.53
30%	15.07	18.49	28.5



The results of the compressive strength of concrete cubes show that the compressive strengths reduced as the percentage **hypo sludge** increased. However, the compressive strengths increased as the number of days of curing increased for each percentage **hypo sludge** replacement. It is seen from Table 2 that for the control cube, the compressive strength increased from 17.51 N/mm^2 at 7 days to 29.15 N/mm^2 at 28 days (i.e. about 66% increment). The 28 day strength was above the specified value of 25N/mm^2 for grade 25 concrete (BS 8110, 1997) as shown in Table 2. The strength of the 5% replacement by **hypo sludge** showed increase in compressive strength from 16.88 N/mm^2 at 7 days to 27.68 N/mm^2 at 28 days (64% increment). The 28 day strength was above the specified value of 25N/mm^2 for grade 25 concrete (BS 8110, 1997) as shown in Table 3. The strength of the 10% replacement by **hypo sludge** showed increase in compressive strength from 12.01 N/mm^2 at 7 days to 20.88 N/mm^2 at 28 days (74% increment). The 28 day strength was above the specified value of 20N/mm^2 for grade20 concrete (BS 8110, 1997) as shown in Table 3.The strength of the 15% replacement by **hypo sludge** showed increase in compressive strength from 11.24 N/mm^2 at 7 days to 18.70 N/mm^2 at 28 days (66% increment). The 28 day strength was above the specified value of 15N/mm^2 for light weight concrete (BS 8110, 1997) as shown in Table 3.The strength of the 20% replacement by **hypo sludge** showed increase in compressive strength from 10.86 N/mm^2 at 7 days to 18.59 N/mm^2 at 28 days (71% increment). The 28 day strength was above the specified value of 15N/mm^2 for light weight concrete (BS 8110, 1997) as shown in Table 3.

Table 3: Recommended grade of concrete (BS 8110, 1997)

Grade	Characteristic strength	Concrete class
7	7.0	Plain concrete
10	10.0	
15	15.0	Reinforced concrete with lightweight aggregate
20	20.0	Reinforced concrete with dense aggregate
25	25.0	
30	30.0	Concrete with post tensioned tendons
40	40.0	Concrete with pre tensioned tendons
50	50.0	
60	60.0	

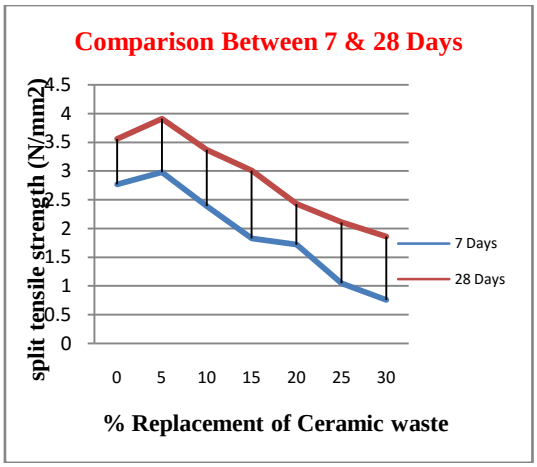
3.3. RESULTS OF SPLIT TENSILE STRENGTH OF CONCRETE

A method used for determining the tensile strength of concrete is by using a cylinder which splits across the vertical diameter. Tensile strength is an important property of concrete because concrete structures are highly vulnerable to tensile cracking due to various kinds of effects and applied loading itself. However, tensile strength of concrete is very low when compared to its compressive strength.

Test for split tensile strength was conducted according to IS: 5816-1970. The specimen cylinders of size 150mm diameter and 300mm long after subjected to temperature exposure for specified duration were released from the furnace and tested for split tensile strength after the specimens were cooled down to normal room temperature conditions. The specimen is placed in the compressive testing machine and the load is applied gradually.

Table 3: Split tensile Strength of Concrete cylinders with various percentages of **hypo sludge**

% Of Sample Replacement	7 Days	28 Days
0%	2.77	3.56
5%	2.98	3.91
10%	2.39	3.37
15%	1.83	3.01
20%	1.72	2.43
25%	1.05	2.11
30%	0.76	1.86



IV. CONCLUSIONS

The following conclusions are drawn from the experimental investigations.

- The Compressive strength of concrete achieves the target strength up to 10% replacement of cement with hypo sludge. Further replacement of cement with hypo sludge there is a decrease in the compressive strength.
- The decrease in compressive strength with the increase in replacement percentage of hypo sludge is due to the presence of low silica content in the composition which tends to decrease in its strength.
- Hypo sludge also contains the other chemicals in which some reactions are carried out in concrete which results in decreasing strength
- The compressive strength of concrete at 10% is stable and when we increase the % of hypo sludge it slightly decreases when compared to normal mix concrete.
- The use of hypo sludge in concrete is not only for decreasing the environmental pollution but also to decrease the cost of construction economically
- Usage of paper industry waste called hypo sludge and its applications are very useful for the development of cement industry and material sciences.
- This is the best way to dispose the paper waste in an effective manner.

V. RECOMMENDATIONS

The following are recommended from this study:

The use of local materials like hypo sludge as pozzolans should be encouraged in concrete production.

Similar studies are recommended for concrete beams and slab sections to ascertain the flexural behavior of lightweight concrete made with this material.

Durability studies of concrete cubes made with hypo sludge as partial replacement for cement should be carried out.

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