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# Effect of Partial Utilization of Wastepaper Sludge on Strength of Concrete

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**Abstract:** ***Due to the increase in industrialization, the production of waste generation in the industries is also increasing .to dispose of this waste generated from the industries a large amount of land is needed .to minimize this problem certain effective methods are to be adopted to reduce this problem. One of the methods is utilizing the waste from paper industries in the cement production. Wastepaper sludge is a by-product of papermaking in the paper mill industries considering the physical and chemical properties of waste lime sludge and a series of possibilities for their use in concrete, this work demonstrates the possibilities of using wastepaper sludge together as a partial replacement of cement in concrete. This work represents the compressive strength, split tensile strength, and fire resistance of concrete by adding wastepaper sludge as a partial replacement of cement in various percentages. In this work, cement has been replaced by four proportions of wastepaper sludge i.e., 5%, 10%, 15%, and 20%. It has been observed for the 7 & 28 days test of compressive strength, split tensile strength, and fire resistance of concrete that compressive strength and split tensile increases up to the 10% of waste paper sludge replacement and thereafter a further increase in % of waste paper sludge the compressive strength and split tensile strength decreases compared to nominal mix .on placing the concrete cubes in the furnace at 1000 c and 2000 c temperature for 60 min the compressive strength of concrete is negligible. A considerable decrease in the compressive strength is observed at 3000, 4000, and 5000 respectively.***

**Keywords:** Concrete, Wastepaper, Strength, Sludge, Fire resistance

## 1. Introduction

Concrete is a heterogeneous combination that is by far the most often used building material today. It's tough to think of another construction material that is as adaptable as concrete. When strength, permanence, durability, permeability, fire resistance, and abrasion resistance are required, it is the material of choice. The material's adaptability, high compressive strength, and the development of reinforcing and prestressing procedures to compensate for its low tensile strength have all contributed to its widespread use. Concrete, unlike other construction materials, is a site-made product with a wide range of quality, characteristics, and performance due to the utilization resources other than cement. Concrete's unique position as a structural material stem stems from its cost-effective resistance to fire, wind, water, and earthquakes. Its application in the building has risen dramatically in recent years. As a result, cities, and towns are transforming into concrete jungles. To keep up with the rising population, housing, transportation, and other facilities, demand is expected to rise in the future.

Special forms of materials with innovative qualities are becoming more necessary as modern engineering methods become more demanding. Scientists, engineers, and technicians are always on the hunt for materials that may be used as substitutes for traditional materials or that have features that allow for new designs and innovations that result in cost savings so that a structure can be created. Individual materials, on the other hand, may not always serve a defined purpose. Many attempts have been made to develop novel materials, which are made up of two or more materials. Composite materials are the name given to such materials.

Concrete is a composite material in the sense that it is made up of several different materials. Greater usage of pozzolanic materials such as fly ash, blast furnace slag, silica fume, stone dust, rice husk ash, wastepaper sludge ash, and wastepaper sludge is recommended to reduce the cost of concrete. The usage of these materials as a concrete substitute will alleviate the current disposal problem faced by thermal power plants and industrial plants while still achieving the needed concrete strength.

Fresh concrete, often known as plastic concrete, is a substance that has been recently mixed and may be molded into any shape. The proportions of cement particles and water that are blended to manage the qualities of concrete in both the wet and cured states. Already, partial replacement of wastepaper sludge for cement is being investigated. It was also discovered that the needed strength may be attained in 28 days with suitable proportioning of wastepaper sludge. Wastepaper sludge was used as a partial replacement for cement in the current study. Wastepaper sludge is a waste product produced in enormous quantities by paper mills each year.

In recent years, the country has established the successful use of wastepaper sludge as a partial replacement for cement as an additive in cement mortar and concrete. A recent examination into the use of wastepaper sludge as a construction material revealed that it has more potential. Increased use of wastepaper sludge will help solve the problem of wastepaper sludge disposal as well as save money on construction materials.

**Wastepaper Sludge:**
In general, papermaking produces a large amount of solid waste. This sort of waste sludge is known as hypo sludge. To reduce disposal land pollution problems, it is necessary

to develop viable building materials from these industrial wastes. The typical makeup of this industrial waste consists of organic material and inorganic minerals (mainly kaolinite and limestone), which are commonly used as loadings in the paper production process. Only so many times can paper fibers be recycled before they become too short or weak to generate high-quality paper. The separation of damaged, low-quality paper fibers into waste sludge is referred to as this. The use of wastepaper sludge in brick can help the paper industry save money on disposal while simultaneously providing greener construction bricks.

Inboard products such as plasterboard, alternative fuels for cement manufacturing, and brick manufacturing are all possible uses for paper sludge in construction products. Recycling waste from paper mills into building materials or other re-use uses is still a viable environmental alternative. Because civil engineering buildings consume large quantities of materials in a short period, the only practical way to recycle these wastes is to employ them in civil engineering builds.

**Table 1:** Chemical composition of wastepaper sludge in India:

| Mineral | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | Cao | MgO | LOI | $SO_3$ | $Na_2O$ |
|---|---|---|---|---|---|---|---|---|
| % | 2-8 | 0.8-5 | 0.8-2.5 | 35-70 | 0.2-10 | 20-50 | 0.2-9 | 0.8-2.0 |

Source: CRI-ENG-SP965 MARCH (2000)

## 2. Materials

**Cement:**
In the presence of water, cement has both cohesive and adhesive capabilities. Hydraulic cement is the name given to such cement. These are generally made up of lime silicates and aluminates derived from limestone and clay. There are various varieties of cement, including ordinary Portland cement and Portland slag cement.

Ordinary Portland cement (OPC) is the most common type of Portland cement and is best used in regular concrete construction. It comes in three different grades: 33, 43, and 53. Portland slag cement is made by combining Portland cement clinker, gypsum, and granulated blast furnace slag in the appropriate proportions and grinding the mixture to achieve a thorough and intimate mixture of the ingredients. This cement, like OPC, can be used for a variety of purposes. It has a lower heat of evolution, is more durable, and can be utilized to produce mass concrete.

**Aggregates:**
Because aggregates account for almost 80% of the total volume of concrete, their characteristics considerably impact its performance. The two forms of aggregates are fine aggregate and coarse aggregate.

Material that passes through an IS sieve with a gauge smaller than 4.75mm is categorized as fine aggregate, after which it is classified as coarse aggregate. The coarse aggregate provides the major matrix for the concrete, while the fine aggregate fills in the crevices between the coarse aggregate. When it comes to coarse aggregate, the most important thing to keep in mind is that only coarse aggregate with a maximum size of 20 mm is suitable for concrete work. However, if there is no restriction, a size of 40 mm or larger may be allowed. When immediate reinforcement is required a 10mm size is also used.

**Wastepaper Sludge:**
The manufacture of paper in the industry generates a significant amount of solid waste. The development of a big volume of solid waste generates challenges with disposal because it necessitates a larger amount of land space for disposal. To some extent, we may solve this problem by using wastepaper sludge in cement manufacture. We can use sludge from the paper industry in cement manufacture because it has chemical elements that are comparable to those found in cement. Cement manufacture releases a large amount of carbon dioxide into the atmosphere, causing a variety of environmental issues. The use of wastepaper sludge in cement manufacture reduces both the amount of carbon dioxide released and the cost of the product is reduced.

**Table 2:** Composition of Wastepaper Sludge (Delta Paper Mill)

| Constituents | $Sio_2$ | $Al_2O_3$ | $Fe_2O_3$ | Cao | MgO | $So_3$ | $Na_2o$ | LOI | MC |
|---|---|---|---|---|---|---|---|---|---|
| **%** | 8 | 1.8 | 1.5 | 58 | 5.41 | 6 | 1.5 | 38 | 40 |

Advantages of Wastepaper sludge

The advantages of adding waste paper sludge as a partial replacement of cement are

- Reduction in cost of production of cement.
- Better utilization of waste from paper industries.
- The problem of landfilling by this waste can be reduced to some extent.
- Environment effects from paper sludge wastes and the maximum amount of cement manufacturing are reduced.

In this work, the wastepaper Sludge is taken from the Delta Paper Mill Industries, Vendra, near bhimavaram, west Godavari district. It is White as shown in the figure. The Physical property of wastepaper sludge is shown in Table.

**Table 3:** Physical properties of wastepaper sludge

| S. NO | Constituents | Value |
|---|---|---|
| 1 | Specific gravity | 2.65 |
| 2 | Colour | White |
| 3 | Fineness | 4% |

**Figure 1:** Showing Wastepaper sludge

**Table 4:** Comparison of chemical properties of cement and **wastepaper sludge:**

| S. No | Constituents | Cement (%) | Waste paper sludge (%) |
|---|---|---|---|
| 1 | $SiO_2$ | 20.6 | 8 |
| 2 | $Al_2O_3$ | 5.07 | 1.8 |
| 3 | $Fe_2O_3$ | 2.90 | 1.5 |
| 4 | CaO | 61 | 58 |
| 5 | MgO | 2.0 | 5.41 |
| 6 | $So_3$ | 2.53 | 6 |
| 7 | $Na_2O$ | 0.4 | 1.5 |

**Water**

The water used in concrete should have the following characteristics: it should be devoid of harmful levels of oil, acids, alkalis, and other organic or inorganic pollutants. It must be free of iron, vegetable debris, and any other substance that could harm the concrete or reinforcement. When utilized in the concrete mixing process, it should be adequate for drinking purposes.

**Machinery and Equipment:**

1) Weight of balances of 1 gm accuracy and 0.01 gm accuracy.
2) Vibration table.
3) Compaction factor and slump cone apparatus.
4) Curing tank.
5) Compression testing machine.
6) Muffle furnace.

## 3. Results and Discussions

The experimental program includes the following: Testing of concrete cubes for finding:

- Compressive strength
- Cylinders for split tensile strength.

Results of compressive strength on concrete with partial replacement of cement by wastepaper sludge at the age of 7 & 28 days are given in the Table. An average of three specimens is taken.

**Compressive strength values for replacement of cement by wastepaper sludge**:

**Figure 2:** Showing compression testing machine

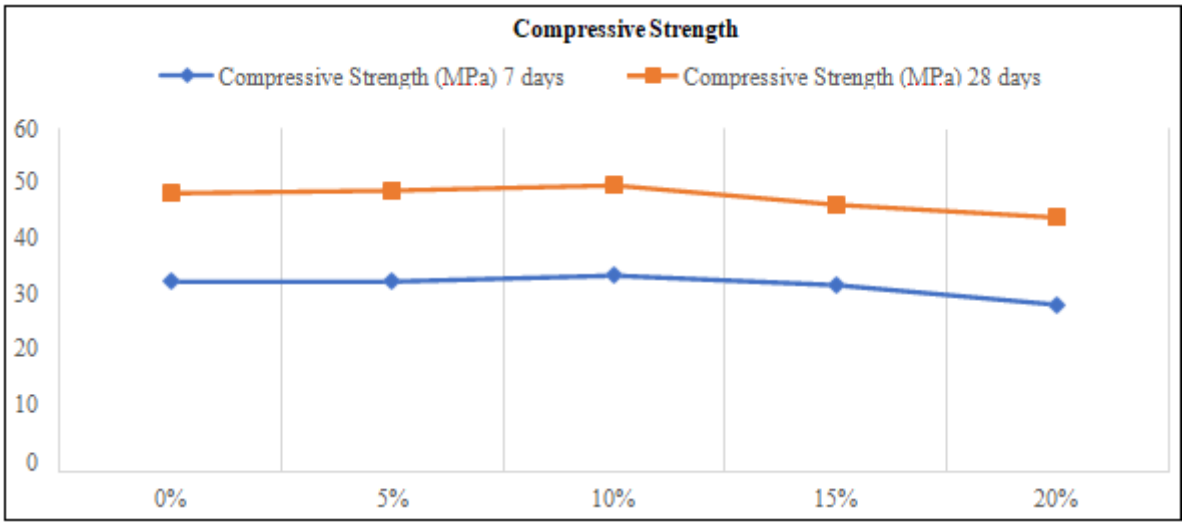
**Figure 3:** Showing failure of the cube

**Figure 4:** Showing cubes in mold

**Figure 5:** Showing curing of the cube

**Table 5:** Compressive Strength Results

| S. No | Mix type | % Replacement of cement By waste paper sludge | Compressive Strength (MPa) | Compressive Strength (MPa) |
|---|---|---|---|---|
| | | | 7 days | 28 days |
| 1 | A0 | 0% | 33.06 | 48.541 |
| 2 | A5 | 5% | 33.136 | 48.977 |
| 3 | A10 | 10% | 34.153 | 49.92 |
| 4 | A15 | 15% | 32.482 | 46.506 |
| 5 | A20 | 20% | 29.066 | 44.32 |




**Graph 1:** Compressive Strength Results

The average test results of three cubes for compressive strength of concrete of all mixes at the age of 7 & 28 days are shown graphically in Figures. From the graphs, it is observed that

On replacement of 5% and 10% of cement by wastepaper sludge in the concrete mix, there is an increase in compressive strength of 0.2% and 3.3% at 7-day, 0.89%, and 2.84% at 28 days is observed when compared to control mix. Further replacement of 15% and 20% of cement by wastepaper sludge in the concrete mix there is a decrease of 1.7% and 12% at 7-day, 4.19% and 8.69% at 28 days is observed when compared to control mix. The strength reduces further if the wastepaper sludge replacement level is increased. Up to a replacement level of 10% of cement with wastepaper sludge desired strength can be achieved. Hence the optimum level of replacement of wastepaper sludge in cement is 10%

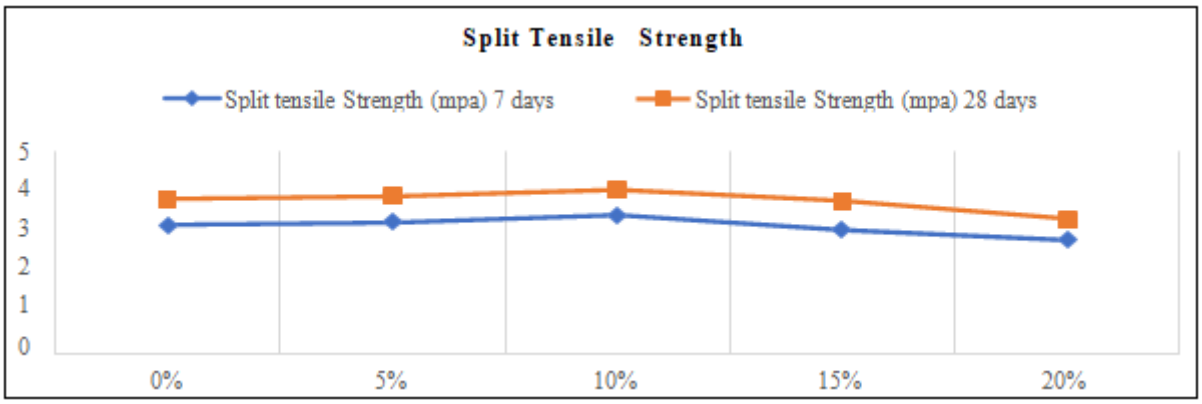
**Split Tensile Strength:**

A split tensile strength test is carried out on the cylinders at the age of 7 & 28 days. The average test results of three concrete cylinders are given in Table. The average results of the split tensile strength on three cylinders are taken.

**Figure 6:** Showing failure of the cylinder

**Table 6:** Split Tensile Strength Results

| S. No | Mix type | % Replacement of cement By waste paper sludge | Split tensile Strength (MPa) 7 days | Split tensile Strength (MPa) 28 days |
|---|---|---|---|---|
| | | | 7 days | 28 days |
| 1 | A0 | 0% | **3.18** | **3.82** |
| 2 | A5 | 5% | **3.23** | **3.88** |
| 3 | A10 | 10% | **3.42** | **4.04** |
| 4 | A15 | 15% | **3.05** | **3.77** |
| 5 | A20 | 20% | **2.80** | 3.33 |




**Graph 2:** Split Tensile Strength Results

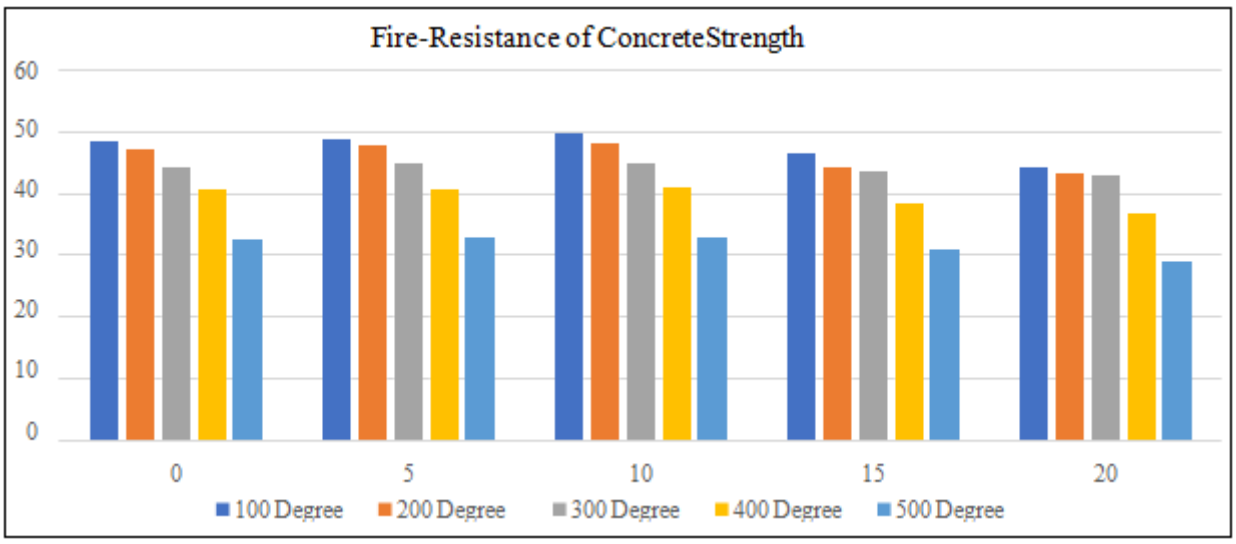
The split tensile strength results for concrete cylinders with partial replacement of cement by wastepaper sludge, in varying proportions, is observed to increase at 5 and 10% replacement level by 1.8% and 7.6% at 7th day, 1.6%, and 3.3% at 28th day is observed when compared to control mix. Further replacement of 15% and 20% of cement by wastepaper sludge in the concrete mix shows a decrease of 3.9% and 11.8% on the 7th day, 1.3% and 13.6% on the 28th day is observed when compared to the control mix. Hence the optimum level of replacement of wastepaper sludge in cement is 10%.

**Fire-Resistance of Concrete**

The concrete cubes are tested for fire resistance at 1000,2000,3000,4000, and 5000 c respectively for 60 minutes in the furnace. Decrease in the compressive strengths of the cubes at the temperatures 1000 and 2000 c is very less. A considerable decrease in the compressive strengths at the temperatures of 3000, 4000, and 5000 c is observed as compared to conventional concrete.

**Table 7:** Fire resistance test results: 28-Days Compressive Strength Results in MPa:

| Temperature | | $100^0$c | $200^0$c | $300^0$c | $400^0$c | $500^0$c |
|---|---|---|---|---|---|---|
| Replacement (%) | Mix type | 28 days strength in MPa | 28 days strength in MPa | 28 days strength in MPa | 28 days strength in MPa | 28 days strength in MPa |
| 0 | A0 | 48.40 | 47.12 | 44.41 | 40.76 | 32.71 |
| 5 | A5 | 48.90 | 47.71 | 44.84 | 40.81 | 32.84 |
| 10 | A10 | 49.91 | 48.06 | 44.96 | 40.96 | 32.98 |
| 15 | A15 | 46.49 | 44.18 | 43.72 | 38.32 | 31.04 |
| 20 | A20 | 44.30 | 43.19 | 42.98 | 36.91 | 29.06 |




**Graph 3:** Fire resistance test results: 28-Days Compressive Strength Results in MPa

**Economic Feasibility**

Cost analysis is carried out for the optimum proportion of percentage of hypo sludge in concrete. This project was carried out on our college campus. The cost is compared to conventional concrete. Cost of materials Cost of cement per bag = Rs.410.00 Cost of sand per 1Tonne = Rs.1100.00 Cost of hypo sludge per kg = Rs.0.50 Cost of coarse aggregate per Tonne = Rs.700.00 (All the rates are included with lead charges)

**Table 8:** Cost of material of normal concrete/m3

| Description | Quantity Kg/m3 | Cost (Rs.) | Cost of material (Rs) |
|---|---|---|---|
| Cement | 432.55 | 8.2/kg | 3546.91 |
| Hypo sludge | _ | 0.50/kg | _ |
| Sand | 561.28 | 1.1/kg | 617.41 |
| Coarse aggregate | 1188.46 | 0.70/kg | 831.922 |
| Total Cost | | | 4997 |

**Table 9:** Cost of material of 10% partially replaced concrete/m3

| Description | Quantity Kg/m3 | Cost (Rs.) | Cost of material (Rs) |
|---|---|---|---|
| Cement | 389.3 | 8.2/kg | 3192.26 |
| Hypo sludge | 43.25 | 0.50/kg | 21.625 |
| Sand | 561.28 | 1.1/kg | 617.41 |
| Coarse aggregate | 1188.46 | 0.70/kg | 831.922 |
| Total Cost | | | 4663 |

The compared values of cost show a decrease in the total cost per cubic meter of concrete. The above table shows a decrease of Rs.334 per cubic meter of concrete when 10% of wastepaper sludge partially replaces concrete.

## 4. Conclusion

The strength characteristics of concrete such as Compressive strength, Split Tensile Strength, and fire resistance of concrete mixtures have been studied in the present work by partial replacement of cement by wastepaper sludge.

**Compressive Strength**

On replacement of 5% and 10% of cement by wastepaper sludge in the concrete mix, there is an increase in compressive strength of 0.2% and 3.3% at 7-days, 0.89%, and 2.84% at 28 days is observed when compared to control mix. Compressive strength of concrete decreases when 15%, 20% of cement is replaced by wastepaper sludge by 1.7% and 12% at 7 days, 4.19%, and 8.69% at 28 days compared to control mix. The increase in strength may be due to the presence of calcium oxide and the fineness of wastepaper sludge. The decrease in strength may be due to excess calcium oxide which leads to the formation of calcium hydroxide, which is not a desirable product in concrete mass.

**Split Tensile Strength:**

The split tensile strength of concrete increases at 5 and 10% replacement level of cement by wastepaper sludge by 1.8% and 7.6% at 7th day, 1.6%, and 3.3% at 28th day when compared to control mix. On 15 and 20% replacement levels of wastepaper sludge in cement, there is a decrease in split tensile strength of 3.9% and 11.8% on the 7th day, 1.3% and 13.6% on the 28th day is observed when compared to the control mix.

**Fire Resistance:**

The cubes are tested for compressive strength after exposing the specimens to temperatures of 1000,2000,3000,4000, and 5000 c respectively in the furnace for 60 minutes. A very nominal decrease in the compressive strengths of cubes at 1000 and 2000 c temperatures is observed compared to the nominal mix.

At 3000 c,4000 c, and 5000 c there is a decrease in the compressive strength of concrete cubes by • 8.51%, 16.02%, 32.61% at 0% replacement of cement by WSP.

- 8.44%, 16.67%, 32.948% at 5% replacement of cement by WSP
- 9.93%, 17.948%, 33.934% at 10% replacement of cement by WSP
- 5.99% ,17.602%, 33.25% at 15% replacement of cement by WSP
- 3.02%, 16.71%, 34.431% at 20% replacement level is observed.

## 5. Scope for Further Research

The present research work is carried out with a partial replacement of cement by wastepaper sludge in concrete. The scope for using wastepaper sludge as a replacement in cement in the future can also be extended. A study on durability characteristics by placing the concrete in acidic and basic environments is needed. Strength properties of concrete with partial replacement of cement with wastepaper sludge need investigation for longer period i.e., 90, 180, and 360days. Fire-resistance of the concrete should be carried out by placing the concrete cubes in the furnace for 30 min, 120 min, and 180 min respectively. Also, along with the replacement of wastepaper sludge in cement, the replacement of fine aggregate and coarse aggregate as another material can be studied in future works.

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