# EXPERIMENTAL STUDY ON CORN COB ASH POWDER AS PARTIAL REPLACEMENT OF CEMENT IN CONCRETE

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**Abstract** *The potential of corn cob ash (CCA) powder as an alternate cementitious material was evaluated in this study. The physical, chemical and mineralogical characteristics of CCA were studied and analyzed. The Compressive strength, Split Tensile strength and Flexural strength of the CCA blended concrete was examined to peruse on the effect of CCA in concrete. The water to binder ratio of 0.40 and 0.55 was considered and concrete with five different dosage of CSA (OPC, 10%, 20%, and 30%) were casted. Results of Compressive strength, Split Tensile strength and Flexural strength revealed that CCA provides a positive effect in the strength development at later ages and in fact has higher percentage gain in strength than the later because of the excellent pozzoloanic effect of CCA in the blended concrete. The NDT test results and chemical analysis of CCA confirmed that CCA has potential to be used as alternate cementitious material. Through the analysis of strength results obtained in this study, it was established that CCA could be blended with cement without adversely affecting the strength properties of concrete.*

*Key Words*: **CCA, concrete, steel, compressive strength, flexural strength, split tensile strength, ductility, absorbed energy**

## 1. INTRODUCTION

The history of cementing materials is as old as the history of engineering construction. Concrete is one of the most widely used building materials today. The versatility and plasticity of the materials, its high compressive strength and discovery of enhanced and pressurized techniques have been widely used. the properties of the concrete in the plastic/hardened state depend on the nature and type of the ingredients used. The modification of building materials has an important impact on the construction industry. A number of attempts have been made in the building materials industry to use waste products, such as supplemental cement (SCM), for useful and cost-effective items. Some studies have focused on finding alternatives that can be used as alternatives to cement, such as industrial and agricultural disposable and less valuable wastes, and their potential benefits can be achieved through recycling, reuse and renewal programs.

These wastes are produced in huge quantities (millions of tons) and are discarded every year. They cause environmental problems and leaching of toxic chemical like arsenic, beryllium, boron, cadmium, chromium, cobalt, lead, manganese, mercury, molybdenum, selenium, strontium, thallium when landfilled or dumped in lakes and oceans. It is shown in studies that waste materials can be successfully used to replace cement and providing environmentally safe, stable and more durable and low cost construction material.

In India, Corn is the third most important food crops after rice and wheat. According to advance estimate, it is cultivated in 8.7 m ha (2010-11) mainly during Kharif season which covers 80% area. Maize in India contributes nearly 9 % in the national food basket and more than ₹100 billion to the agricultural GDP at current prices apart from the generating employment to over 100 million man-days at the farm and downstream agricultural and industrial sectors. The use of corncob ash in concrete with normal strength is a new dimension of concrete agitation design, and if large-scale applications will reform the construction industry through cost savings. Pozzolanas have been used to improve properties of cement mortar and concrete. Pozzolanas, by their diverse and varied nature, tend to have widely varying characteristics. The chemical composition of pozzolanas varies considerably, depending on the source and the preparation technique. Generally, a pozzolana will contain silica, alumina, iron oxide and a variety of oxides and alkalis, each in varying degrees. ). Use corn cob ash (CCA) as a pozzolana, without considering this chemical CCA suitable for use as pozzolana. In this study, it is working to produce CCA mixed cement in a factory controlled environment because it is an ordinary portland cement. The CCA used is produced by grinding the dried corn mandrel to a diameter of about 4.00 mm to enhance sufficient combustion and reduce the impact pozzolana properties of CCA.

## 2. EXPERIMENTAL INVESTIGATION

The commonly used mix of 20 MPa was used for this study. The concrete mix design was done as per IS 456:2000 and IS 10262:2009. The materials were tested for various properties needed for the mix design. The cement used for the entire experiment is Ordinary Portland Cement of grade 53 cement. The coarse aggregates were of size 20 mm and downgraded and the fine aggregate used was M-sand.

Water to binder ratio (0.55) and three different replacement percentages (OPC, 10%, 20%, and 30% by weight of cement) were adopted. For each replacement percentage, three samples were casted for the experiments (3 specimens for 7 days, 3 specimens for 28 days, 3 specimens for 56 days and 3 specimens for 90 days) and average of the three results has been reported in this paper. The concrete mix was prepared to have a design compressive strength of 20 N/mm2 at 28 days.

The waste of concern in this study is corn cob ash (CCA). Use corn cob ash (CCA) as a pozzolana, without considering this chemical CCA suitable for use as pozzolana. Use a local blacksmith furnace using charcoal as a fuel, burning ground coke in the open air.

Tests carried on the hardened concrete were compressive strength test (Conforming to IS 516:2000), flexural strength test (conforming to IS 516:2000) and splitting tensile strength test (conforming to IS 5816:2000). Mechanical tests were performed at 7 days , 28 days, 56 days and 90 days on three specimens. A digital compression testing machine (conforming to IS 516:2000) was used for compressive strength and splitting tensile strength. For flexural strength test 3 point loading system was employed. The maximum load at failure was taken for strength comparison. Table 1 represent chemical properties of OPC 53 and table 2 represent chemical properties of corn cob ash.

**Table 1 chemical properties of the cement**

| | Particular | Value |
|---|---|---|
| | **Chemical properties** | |
| 1 | $SiO_2$ (%) | 20.02 |
| 2 | $Al_2O_3$ (%) | 4.70 |
| 3 | $Fe_2O_3$ (%) | 3 |
| 4. | CaO (%) | 61.9 |
| 5. | MgO (%) | 2.60 |
| 6. | $Na_2O$ (%) | 0.19 |
| 7. | $K_2O$ (%) | 0.82 |
| 8. | $SO_3$(%) | 3.9 |
| 9 | Loss of Ignition | 1.9 |

**Table 2 chemical properties of the CCA**

| | Particular | Value |
|---|---|---|
| | **Chemical properties** | |
| 1 | $SiO_2$ (%) | 62.30 |
| 2 | $Al_2O_3$ (%) | 6.25 |
| 3 | $Fe_2O_3$ (%) | 4.40 |
| 4. | CaO (%) | 10.57 |
| 5. | MgO (%) | 1.86 |
| 6. | $Na_2O$ (%) | 0.36 |
| 7. | $K_2O$ (%) | 3.89 |
| 8. | $SO_3$ (%) | 1.02 |

## 2. RESULTS AND DISCUSSION

### Physical and chemical analysis of CCA and cement

The physical properties of cement and CCA are given in Table 1 and Table 2. The specific gravity and mean size of CCA was found to be less than that of cement. Chemical composition data for the cement and CCA is also presented in Table 1 and Table 2. This particular specimen of CCA contains 62.30% of silica as related in Table 2. The total percentage of Iron Oxide, Silicon Oxide and Aluminium Oxide when added together was greater than the minimum 70% specified by for pozzolanas (ASTM 618, 2005). The high percentage of silicon oxide is beneficial in pozzolanic reaction with time.

### Compressive strength

Table 3 presents the results of compressive strength of CCA blended cement concrete. The test was perfrom at age of 7 days, 28 days , 56 days and 90 days. This observation is also reported by many researchers alike as Adesanya A, Raheem A, (2009) who reported that compressive strength of concrete having variable replacement percentage of CCA was lower than that of control specimen at 7, 28 and 56 days and showed that the 90 days compressive strength of concrete with variable replacement percentage of CCA was higher than the corresponding concrete mixtures without CCA.

**Table 3 Result of compressive strength**

| Water to binder ratio | Replacement percentage (%) | Compressive strength (N/mm2) | | | |
|---|---|---|---|---|---|
| | | 7 day | 28 days | 56 days | 90 day |
| 0.55 | 0 | 16.22 | 24.04 | 27.76 | 34.06 |
| | 10 | 14.67 | 22.68 | 27.16 | 36.07 |
| | 20 | 12.96 | 21.85 | 26 | 33.6 |
| | 30 | 11.36 | 20.87 | 23.48 | 30.81 |

However insignificant improvement in strength was observed for CCA blended concrete at lower ages. This can be attributed to the fact that pozzolanic reaction is slow at early age's strength.

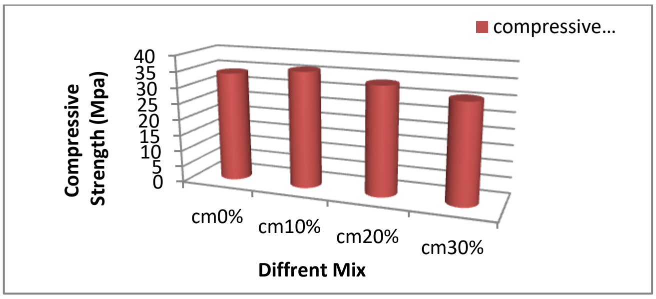


**Chart 1 Comparison of Compressive Strength of cubes after 90 days**

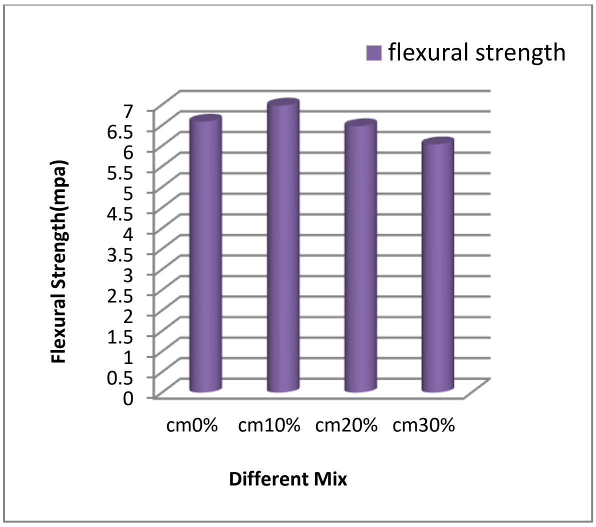


**Chart 2 Comparison of Flexural Strength of cubes after 90 days**

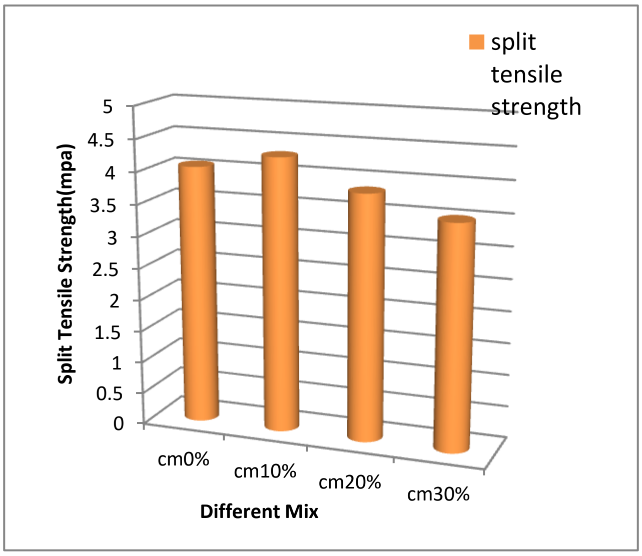


**Chart 3 Comparison of Split Tensile Strength of cubes after 90 days**

**Table 4 Result of compressive strength**

| Water to binder ratio | Replacement percentage (%) | Flexural strength (N/mm2) | | |
|---|---|---|---|---|
| | | 28 days | 56 days | 90 day |
| 0.55 | 0 | 4.75 | 6.04 | 6.59 |
| | 10 | 4.68 | 5.98 | 6.98 |
| | 20 | 4.51 | 5.76 | 6.44 |
| | 30 | 4.19 | 5.44 | 6.04 |

**Table 5 Result of compressive strength**

| Water to binder ratio | Replacement percentage (%) | Split tensile strength (N/mm2) | | |
|---|---|---|---|---|
| | | 28 days | 56 days | 90 day |
| 0.55 | 0 | 3.41 | 3.82 | 4.06 |
| | 10 | 3.02 | 3.65 | 4.29 |
| | 20 | 2.64 | 3.48 | 3.84 |
| | 30 | 2.26 | 3.11 | 3.51 |

## Flexural strength

The flexural strength of CCA blended concrete at 28 days, 56 days and 90 days is presented in Table 4. Flexural strength result presents a complicated result pattern. Flexural strength also showed the same trend of higher strength in CCA blended concrete having higher age (90 days) as compared to control specimen however the increased was less pronounced as compared to compressive strength. It shows that pozolonic activity was continued after curing period at 90 days. Chart 2 present values of flexural strength increases at 10% replacement of cement at 90 days.

## Split tensile strength

The split tensile strengths of CCA blended concrete at 28 days, 56 days and 90 days is presented in Table 5. Split tensile strength also showed the same trend of higher strength in CCA blended concrete having higher age (90 days) as compared to control specimen however the increased was less pronounced as compared to compressive strength. Chart 3 present values of split tensile strength increases at 10% replacement of cement at 90 days.

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## Non-destructive testing analysis

Non destructive test (NDT) of the CCA was performed using rebound hammer and Ultrasonic pulse velocity test specimen of M20 grade concrete. This analysis was provides immediate results and actual strength and properties of concrete structure.

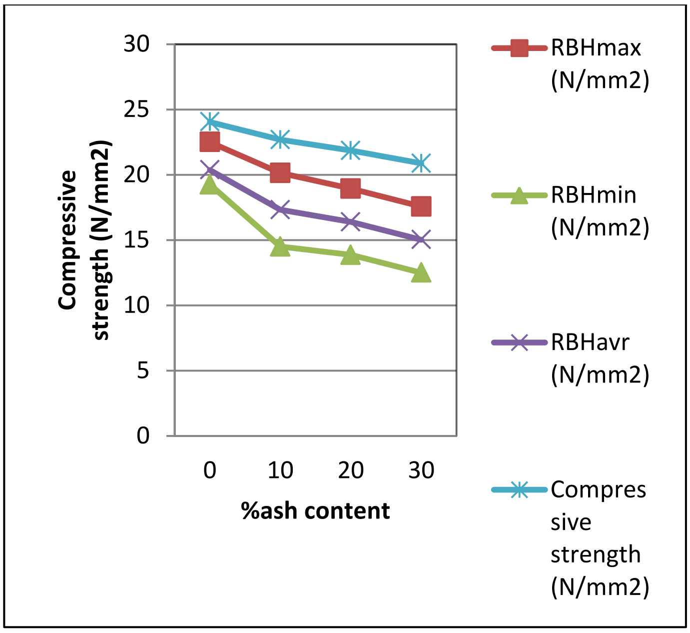


**Chart 4 variations in 28 days compressive strength results**

Chart 1 presents the NDT pattern of the CCA sample. Test is carried out at 28 day and as replacement of CCA by 10%, 20% and 30%. Rebound hammer maximum, minimum and average values are consider for experimental result purpose. However as shown in figure value of compressive strength is decreases with increases in percentage ash content.

## 3. CONCLUSIONS

Following are conclusions drawn on the basis of the results obtained from the experimental works:

i. Corn Cob Ash (CCA) is a suitablepozzolana material because it meets the material requirements by making the combination of SiO2 and Al2O3 more than 70%

ii. The compressive strength of CCA-blended cement concrete is lower than that of plain concrete (the control) at early curing ages but improves significantly at later ages and in fact has higher percentage gain in strength than the later.

iii. The CCA can be used to replace 10% of the concrete in concrete production because this alternative reduces the strength of the concrete beyond the control.

iv. A considerable improvement in the flexural strength and split tensile strength was seen at 10% replacement of cement

v. Rebound hammer value decreased with amount of CCA increased.

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