# 废纸煤灰部分替代混凝土中的水泥

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**摘 要：**

0% 5% 10% 15% 20%
C–25

10%
7 28
10% 5% 10%
5.6% 1.2% 10% 5%
37.89kN/m2

**关键词：**

## Waste Paper Ash as Partial Replacement of Cement in Concrete

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**Abstract:** Concrete is one of the versatile and widely used building materials in the world construction industry. Cement being the main binder in concrete, its production process is both uneconomical and environmental unfriendly. In order to alleviate these problems, the use of alternative materials which have lower cost of production, lower emission of CO2, and lower energy consumption, were being implemented. Therefore, the aim of this study is to investigate the effects of waste paper ash as cement replacement material in concrete production. Accordingly, chemical compositions of waste paper ash were investigated and cement was replaced by waste paper ash in a range of 0%, 5%, 10%, 15%, and 20%. To examine the suitability of paper ash for concrete production, its' effect on both fresh and hardened properties of C – 25 concrete was studied. From result of this study, it was observed that, the chemical compositions of waste paper ash were not fulfill the requirements of Pozzolanic material. Paper ash has lengthened the setting times of blended cement paste and its normal consistency was increased. The cement paste with replacement up to 10% showed a normal consistency with in standard range. Workability of the concrete was tested immediately after preparing the concrete mix whereas the compressive strength tests were tested after 7, and 28 days of curing. The results indicated that workability of concrete containing waste paper ash decreases as the waste paper ash content increases. There is significant improvement in compressive strength of concrete. Replacement of ordinary Portland cement by waste paper ash up to 10% resulted in a better compressive strength than that of the convectional mix. An enhancement of 5.6% & 1.2% were observed for 5%, & 10% of replacement respectively. But the compressive strength decreases as the waste paper ash replacement increases over 10%. A highest compressive strength of 37.89kN/m$^2$ was obtained for concrete containing 5% of waste paper ash.

**Keywords:** Cement; Concrete; Partial replacement; Properties of concrete; Waste paper ash

## 1.引言

/ 1 1.5
[1] Malhotra 1988 Swamy 1998
4–7 MJ

[16 17] 1

SCM

2016 Savita D.

[2]

Ali 2013 4.5

2020 5

[10] Asmare 2015 2015/16

157956.7

[9]

Oriyomi M.O.

[3]

$SiO_2$ 60% CaO 14% $Al_2O_3$ 2.06%

$Fe_2O_3$ 0.92%

Sumit, A. B. , 2013

## 2.材料和方法

OPC

2.1

2.1.1.

42.5 Dangote

OPC ES C.D5

201

2.1.2.

4.75mm

4.54%

5% [7] 2.8 ASTM C33

2.3 3.1[5] 1

| No. | Test description | | Test result |
|---|---|---|---|
| 1 | Silt content | | 4.54% |
| 2 | Moisture content | | 1.6% |
| 3 | Unit weight (Compacted): | | 1437.3kg/m$^3$ |
| 4 | Absorption capacity | | 2.04% |
| 5 | Specific gravity: | Bulk | 2.65 |
| | | Bulk (SSD) | 2.70 |
| | | Apparent | 2.80 |
| 6 | Fines Modules | | 2.8 |

1.

2.1.3.

20mm

2

| No. | Test description | | Test result |
|---|---|---|---|
| 1 | Maximum size | | 20mm |
| 2 | Moisture content | | 1% |
| | Unit weight compacted | | 1591.35kg/m$^3$ |
| 4 | Absorption capacity | | 1% |
| 5 | Specific gravity: | Bulk | 2.77 |
| | | Bulk (SSD) | 2.80 |
| | | Apparent | 2.86 |

2.

2.1.4.

850℃

7.4μm

A.M.Neville

[8]

2.2.

ACI

[4] C-25

33.5MPa 1:2.35:3

5% 10%

15% 20%

ASTM C192 [6]

7 28

## 3.结果和讨论

3.1.

SCM

3

| Chemical Composition (%) | Waste paper Ash |
|---|---|
| $SiO_2$ | 29.20 |
| $Al_2O_3$ | 2.65 |
| CaO | 50.88 |
| $Fe_2O_3$ | 1.74 |
| MgO | 0.86 |
| $Na_2O$ | 0.30 |
| $K_2O$ | <0.01 |
| MnO | <0.01 |
| $P_2O_5$ | 0.67 |
| $TiO_2$ | <0.01 |
| $H_2O$ | 0.62 |
| LOI | 12.52 |
| $SO_3$ | 0.51 |

3.

$SiO_2+Al_2O_3+Fe_2O_3$ 33.59%

70% ASTM C-618

CaO

$SiO_2$

OPC

2.65%

1.74

$TiO_2$ $MnO_2$

$P_2O_3$ 1%

2006

Sumit 2013

Si 60% Ca 14% [11]

Si 29.20% Ca 50.88%

LOI 12.52%

10%

BS EN

197-1:2000 1000°C 5%[14] ASTM

C 150-07 3% I 2.5%

[15] 4%

3.2.

4

| No | % of replacement | Initial setting Time (Min.) | Final setting Time (Min.) |
|---|---|---|---|
| 1 | 0% | 176 | 301.2 |
| 2 | 5%WPA | 208 | 339.6 |
| 3 | 10%WPA | 220 | 354 |
| 4 | 15%WPA | 225 | 360 |
| 5 | 20%WPA | 250 | 390 |

4.

$C_3A$ $CaSO_4.2H_2O$

OPC $C_3A$

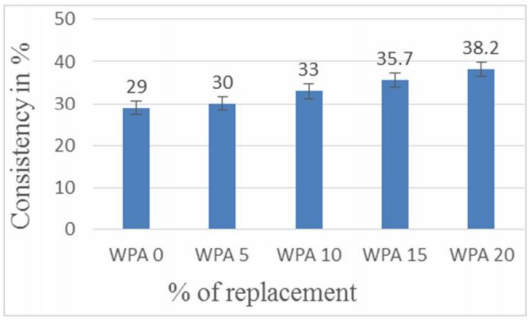
$C_3A$

45

10

3.3.

1




1.

29%

26% 33% [11]

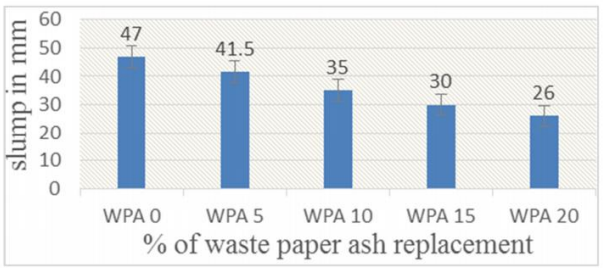
10%

10%

3.4

ASTM C 143

2




2.

20%

30-50

Sumit 2013

5%

5%

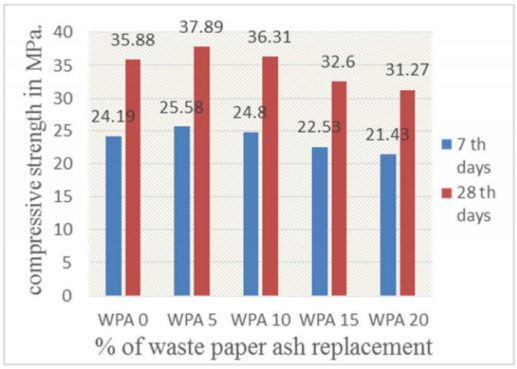
[11]

3.5.

2000KN

150mm X 150mm X 150mm 7 28

3 5 7 28




3. 7 28

10%

28

5% 10% 5.6%

1.2%

15% 20%

[Sumit 2013

H.Yun 2007 ]

2007 H. Yun

5% 34

MPa[12]

Sumit 2013

10%

[11]

| S/N | Mix code | % of replacement | Average Compressive strength in N/mm2 | | | |
|---|---|---|---|---|---|---|
| | | | 7th day | Increment in % | 28th day | Increment in % |
| 1 | WPA 0 | OPC | 24.19 | | 35.88 | |
| 2 | WPA 5 | 95%OPC+5%WPA | 25.58 | 5.43% | 37.89 | 5.6% |
| 3 | WPA 10 | 90%OPC+10%WPA | 24.8 | 2.52 | 36.31 | 1.2% |

| S/N | Mix code | % of replacement | Average Compressive strength in N/mm2 | | | |
|---|---|---|---|---|---|---|
| | | | 7th day | Increment in % | 28th day | Increment in % |
| 4 | WPA 15 | 85%OPC+15%WPA | 22.53 | - 6.86% | 32.60 | - 9.14% |
| 5 | WPA 20 | 805%OPC+20%WPA | 21.43 | - 11.40% | 31.27 | - 12.84% |

5.

3.6.

7 28

0.0038 $m^3$

6

| S. N | % of replacement | Unit wt. ($kg/m^3$) | Reduction in (%) |
|---|---|---|---|
| 1 | OPC | 2444.44 | |
| 2 | 95%OPC+5%WPA | 2419.95 | 1% |
| 3 | 90%OPC+10%WPA | 2392.88 | 1.12% |
| 4 | 85%OPC+15%WPA | 2359.79 | 1.4% |
| 5 | 805%OPC+20%WPA | 2311.52 | 2.05 |

6.

2200-22400kg/$m^3$

[1]

H. Yun 2007

[12] Shivangani

Khandelwal 2015

[13]

## 4.结论

ASTM C 618

$SiO_2+Al_2O_3+Fe_2O_3$ 70%

70%

10%

5%

37.89kN/$m^2$ 10%

20%

2.05%

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