

Effects of Wood Ash and Waste Glass Powder on Properties of Concrete in Terms of Workability and Compressive Strength in Jaresh City

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Abstract

The potential for using fly ash as a supplementary cementing material in concrete has been known almost since the beginning of the previous century. Fly ash was used as a supplementary cementing material (SCM) in the production of Portland cement concrete. A supplementary cementing material, when used in conjunction with Portland cement, contributes to the properties of the hardened concrete through hydraulic or pozzolanic activity, or both. In this study, the fly ash and waste glass powder were used in concrete blocks to study the improvement of concrete in terms of workability and strength. Therefore, an experimental study will be conducted to measure the engineering properties of cured concrete. In this research, local raw material from Jaresh area was used.

Keywords

Fly Ash, Waste Glass Powder, Supplementary Cementing Material, Compressive Strength, Workability

1. Introduction

In recent decades, research has demonstrated that high dosage levels of fly ash (40% to 60%) can be used in structural application producing concrete with good mechanical properties and durability (Marceau 2002) [1]. The use of good quality fly ash with a high fineness and low carbon content reduces the water demand of concrete and, consequently, the use of fly ash should permit the concrete to be produced at lower water content when compared to a Portland cement concrete of the same workability. Although the exact amount of water reduction varies widely with the nature of the fly ash and other parameters of the

mix. A well-proportioned fly ash concrete mixture will have improved workability when compared with a Portland cement concrete of the same slump. This means that, at a given slump, fly ash concrete flows and consolidates better than a conventional Portland cement concrete when vibrated. The use of fly ash also improves the cohesiveness and reduces segregation of concrete. The spherical particle shape lubricates the mix rendering it easier to pump and reducing wear on equipment. The main objective of this paper was to develop a mixture design of concrete with fly ash and waste glass powder to produce concrete with high compressive strength comparing to normal concrete samples. Another objective was to reduce some industrial waste material on the environment such as fly ash and waste glass, which causes environment pollution.

2. Literature Review

Baboo Rai *et al.* (2011) [2] used marble powder and its granules as partial replacement for the fine aggregate. Using these materials, cement mortar and concrete were prepared. Afterwards, the relative workability test, compressive strength test and flexural strength test were conducted. Based on the test results, they concluded that when the percentage of marble powder added in concrete increases, the compressive strength and flexural strength of concrete also increase.

Akshay C. Sankh *et al.* (2009) [3] stated that there is a need to find the new alternative material to replace the river sand, such that excess river erosion and harm to environment is prevented. Many researchers are finding different materials to replace sand and one of the major materials is quarry stone dust. Using different proportion of these quarry dust along with sand, the required concrete mix can be obtained. This paper presents a review of the different alternatives to natural sand in preparation of mortar and concrete. The paper emphasizes on the physical and mechanical properties and strength aspect on mortar and concrete.

Belachia M. *et al.* (2011) [4] used the recycled aggregates in the making of hydraulic concrete. Properties like density, workability, compressive strength and flexural strength of the hydraulic concrete were found and compared with the properties of conventional concrete. The optimum percentage of recycled aggregate found from the comparative study was 25% for the ultimate strength and 50% for the ultimate density.

Goliya, H.S. *et al.* (2008) and ACI Committee 232 [5] [6] conducted a research with the aim of identifying a suitable alternative for concrete ingredients. Cement is replaced by fly ash, stone dust, ground granulated blast-furnace slag etc. and sand is replaced by stone dust, fly ash etc., Ravina, D. and Mehta, P. K. [7] [8]. to find out the strength properties, such as the compressive strength and flexural strength of concrete, and this through a partial replacement of both cement and sand by glass powder as a pozzolana and by pond ash in concrete respectively.

Leema Rose. A *et al.* (2011) [9] showed that glass powder is obtained as a waste material after the extraction and processing of glass to form fine particles less than 4.75 mm. Glass powder has been used in large scale in highways as a surface finishing material and also used in the manufacture of hollow blocks and light weight concrete prefabricated elements.

Monica *et al.* (2013) and ACAA, 2005 Coal Combustion Product [10] [11] used various alternate materials like marble powder, quarry dust, wood ash and paper pulp in concrete as a replacement of cement in making concrete. In this paper, they concluded that, by using these materials in concrete, nearly 14% to 20% of cement was saved. Chemical properties of concrete like sulfate attack resistance and alkali aggregate resistance were increased while using these materials. By using these waste materials in concrete, the problems in disposal of these materials on lands get reduced and the environmental pollution is prevented.

3. Research Approach

To achieve these goals, experimental laboratory tests of concrete block samples were conducted to achieve a compressive strength of 25 MPa According: ASTM (211.1-81). The methodology of this research was divided in two main categories with the following fly ash and waste glass powder ratio:

- 1) Cube concrete specimen (three samples):
 - Null (fly ash/waste glass powder)
 - 10% of cement ratio of (fly ash/waste glass powder)
 - 20% of cement ratio of (fly ash/waste glass powder)
- 2) Cylinder concrete specimen three samples):
 - Null (fly ash/waste glass powder)
 - 10% of cement ratio of (fly ash/waste glass powder)
 - 20% of cement ratio of (fly ash/waste glass powder)

4. Work Plan and Experimental Matrix

Concrete Mix Design

According to ASTM (211.1-81) and NEVILL, we chose specific compressive strength 25 MPA with a slump 50 mm and weight coarse aggregate 1600 kg/m³, with maximum w/c ratio 0.5 and water content 180 kg/m³ and approximate entrapped air content per cent 1.5%.

• Specimen Preparation

In this research, a mix design of concrete with powder of fly ash and waste glass were used to measure and evaluate the compressive strength of concrete. The following ratio of additive powder (fly ash and waste glass) was used according to the ratio of cement:

- Null (no additive), three samples.
- A cement ratio of 10% (fly ash and waste glass powder), at age 7 days and 28 days, three samples each for cube blocks, and two samples each for cylindri-

cal samples.

- A cement ratio of 20% (fly ash and waste glass powder), at age 7 days and 28 days, three samples each for cube blocks, and two samples each for cylindrical samples.
- **Table 1** illustrates the ratio of raw material used in concrete mix design to obtain a target compressive strength of 25MPa.

- **Sample Preparation and Notation**

In this research, the samples are classified as follow:

- **Pure Concrete Cube Sample** (0%, No additive material): **PCCS**
- **Glass Concrete Cube Sample** (with a ratio of 10% and 20%): **GCCS**
- **Fly Ash Concrete Cube Sample** (with a ratio of 10% and 20%): **FACCS**
- **Pure Concrete Cylindrical Sample** (0%, No additive material): **PCYS**
- **Glass Concrete Cylindrical Sample** (with a ratio of 10% and 20%): **GCYS**
- **Fly Ash Concrete Cylindrical Sample** (with a ratio of 10% and 20%): **FACCYS**

5. Results Analysis and Discussion

In this study, a concrete specimen compression test was carried out for two types of cube concrete block samples (150 × 150 × 150 mm) and cylindrical concrete samples (with a diameter of 150 mm and a length of 300 mm).

Compression Test of Cube/Cylindrical Specimen at Age 7 Days (0% - 10%)

The results of the compression test of cube samples with no additive materials at age 7 days show that the average compressive strength is 20.66 MPa and the specific compressive strength is 9.4 MPa. On the other hand, by adding 10% of waste glass powder, the average compressive strength is 21.3 MPa and the specific compressive strength 9.7 MPa. The average compressive strength of 10% fly ash is 31.7 MPa, and the specific compressive strength is 14.4 MPa.

The results of the compression test of cylindrical samples with no additive materials at age 7 days show that the average compressive strength is 18.7 MPa and the specific compressive strength is 8.5 MPa. On the other hand, by adding 10% of waste glass powder, the average compressive strength is 19.4 MPa and the Specific compressive strength is 8.8 MPa. The average compressive strength of 10% fly ash is 23.9 MPa, and the specific compressive strength is 10.7 MPa. **Table 2** shows the result values.

Compression Test of Cube/Cylindrical Specimen at Age 7 Days (20%)

Table 1. Illustrates the ratio of raw material used in concrete mix design.

Materials	Wt/m ³	Ratio (%)
Water	180	7.64
Cement	360	15.28
Fine Aggregate (Sand)	791	33.6
Course Aggregate	1024	43.48

Table 2. Illustrates test results for all samples.

Sample type	Sample composition	Sample Age	Average compressive strength (MPa)	Standard Error	Specific compressive strength (MPa/Kg/m ³)
Glass Powder%					
cube	0	7	20.66	0.063	9.4
-	10	7	21.3	0.033	9.7
-	20	7	14.3	0.088	6.5
Cylindrical	0	7	18.7	0.061	8.5
-	10	7	19.4	0.033	8.8
-	20	7	8.6	0.02	3.9
Fly Ash%					
cube	10	7	31.7	0.052	14.4
-	20	7	6.5	0.057	2.9
Cylindrical	10	7	23.9	0.088	10.7
-	20	7	6.3	0.03	2.9
Glass Powder%					
cube	0	28	24.8	0.031	11.3
-	10	28	24.6	0.020	11.2
-	20	28	16.4	0.012	7.5
Cylindrical	0	28	21.7	0.031	9.9
-	10	28	19.95	0.038	9.1
-	20	28	9.12	0.010	4.1
Fly Ash%					
cube	10	28	32.5	0.033	14.8
-	20	28	12.6	0.029	5.7
Cylindrical	10	28	29.6	0.033	13.5
-	20	28	7.41	0.017	3.4

By adding 20% of waste glass powder, the results of the compression test of cube samples at age 7 days show that the average compressive strength is 14.3 MPa and the Specific compressive strength is 6.5. The average compressive strength of 20% fly ash is 6.5 MPa, and the specific compressive strength is 2.98 MPa.

The results of the compression test of cylindrical samples at age 7 days with adding 20% of waste glass powder, the average compressive strength is 8.6 MPa and the specific compressive strength is 3.9 MPa. The average compressive strength of 20% fly ash is 6.3 MPa, and the specific compressive strength is 2.9 MPa. **Table 2** shows the result values, and **Figure 1** shows average compressive

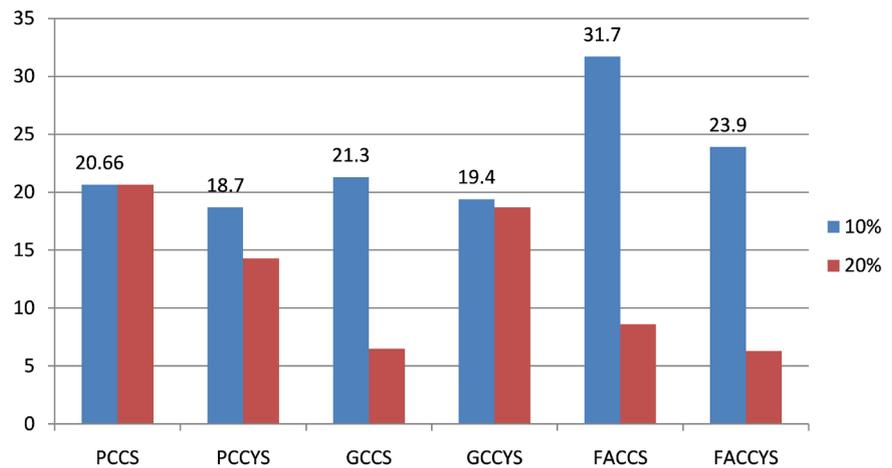


Figure 1. Shows the compressive strength at age 7 days for (Null, 10%, 20%) additive materials.

strength for cube/cylindrical sample at age 7 days.

Compression Test of Cube /Cylindrical Specimen at Age 28 Days (0% - 10%)

The results of the compression test of cube samples with no additive material at age 28 days show that the average compressive strength is 24.8 MPa and the specific compressive strength is 11.3 MPa. On the other hand, by adding 10% of waste glass powder, the average compressive strength is 24.6 MPa and the Specific compressive strength is 11.2 MPa. The average compressive strength of 10% fly ash is 32.5 MPa, and the specific compressive strength is 14.8 MPa.

The results of the compression test of cylindrical samples with no additive material at age 28 days show that the average compressive strength is 21.7 MPa and the specific compressive strength is 9.9 MPa. On the other hand, by adding 10% of waste glass powder the average compressive strength is 19.95 MPa and the Specific compressive strength is 9.1. The average compressive strength of 10% fly ash is 29.6 MPa, and the specific compressive strength is 13.5 MPa. **Table 2** shows the result values.

Compression Test of Cube/Cylindrical Specimen at Age 28 Days (20%)

By adding 20% of waste glass powder, the average compressive strength of cube sample is 16.4 MPa and the Specific compressive strength is 7.5 MPa. The average compressive strength of 20% fly ash is 12.6 MPa, and the specific compressive strength is 5.7 MPa.

The results of compression test of cylindrical samples at age 28 days with 20% waste glass powder show that the average compressive strength is 9.12 MPa and the Specific compressive strength is 4.1 MPa. The average compressive strength of 20% fly ash is 7.41 MPa, and the specific compressive strength is 3.4 MPa. **Table 2** shows the result values, and **Figure 2** shows average compressive strength for cube/cylindrical sample at age 28 days.

According to the results analysis the following results discussion were drawn:

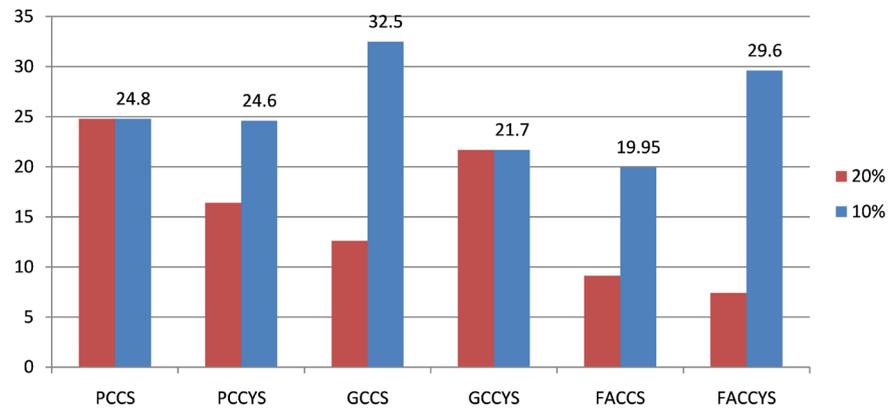


Figure 2. Shows the compressive strength at age 28 days for (Null, 10%, 20%) additive materials.

- Adding 10% of fly ash to concrete mixture has a significant effect to improve the compressive strength of concrete cube specimens at age 7 days, it can be reached 53%. This is can also be linked to the work of Goliya. H. S *et al.* (2008) [5] who suggested that the fly ash can be used in concrete as a replacement of cement in making concrete. On the other had, the compressive strength were increased by 3% by adding 10% of waste glass.
- Adding 20% of fly ash of concrete cube result in reduction of compressive strength at age 7 days by 69%, so that it can be ststed that adding 20% of fly ash gave a remarkable decrease of compressive stregnth of concrete. whereas adding 20% of waste glass to the concrete mixture resluted in decreasing of compressive strength by 33%. The standard error for all samples at age 7 days range between 0.02 - 0.088, which indicated of the accuracy of the average value of compressive strength.
- At age 28 days the average compressive strength of concrete cube specimen were increased 31% by adding 10% of fly ash, so that this ratio of additive material is preferable to increase concrete strength. However, no remarkable increase of compressive strength by adding 10% of waste glass.
- Adding 20% of fly ash result in decreasing of compressive strength of concrete cube at age 28 days by 49%, so that this ratio of additive material is not preferable and gave significant reduction of compressive stregnth of concrete. Whereas 20% of waste glass resulted in decrease of compressive stregnth by 33%.
- For cylindrical concrete samples, the average compressive strength at age 7 days was increased by 27% by adding 10% of fly ash, so that 10% of fly ash was preferable ratio to achive a desire compressive strength. On the other hand, slight increase of compressive strength was observed when 10% of waste glass was added.
- Adding 20% of fly ash resulted in significant decrease of compressive strength 67%, so that this ratio of additive materail was not preferable. on the other hand, the average compressive strength was decrease by 54% by adding 20%

of waste glass.

- The average compressive strength for cylindrical specimen at age 28 days was increased by 36% when 10% of flyash was added, whereas an 8% decrease in compressive strength is measured, when 10% of waste glass was added. So that 10% of fly ash gave high increased of compressive strength of concrete. However, 66% decreased of compressive strength was measured by adding 20% of fly ashve. So that 20% of fly ash or more gave significant decreased of compressive strength of concrete, whereas the average compressive strength decreased by 58% by adding 20% of waste glass. The standard error for all samples at age 7 days range between 0.01 - 0.038, which indicated of the accuracy of the average value of compressive strength.

6. Conclusions and Recommendations

The following conclusions are drawn based on the laboratory test results used in this study:

- It has been observed that adding 10% of fly ash or waste glass on concrete has a significant effect on increasing the compressive strength of concrete cube samples at age 7 days, with a range between 53% and 3%.
- The measurements show that the compressive strength of concrete is increased by 31%, when 10% of fly ash is added and a 1% reduction of compressive strength is achieved, by adding 10% of waste glass on concrete at age 28 days.
- The measurements show that the reduction of compressive strength of concrete at age 7 days varies between 69% and 30%, when 20% of waste glass and fly ash is added to concrete.
- It has been observed that adding 10% of fly ash or waste glass to concrete resulted in an increase in the compressive strength of concrete cube samples at age 28 days, ranging between 31% and 1% respectively. It is also observed that there was a significant reduction of compressive strength at age 28 days, ranging between 33% and 49%, when adding 20% of waste glass and fly ash respectively.
- In conclusion, adding 20% of waste glass or fly ash is not recommended, since it leads to a significant decrease in the compressive strength of concrete.
- Adding 10% of fly ash results in a significant increase in the compressive strength of concrete.
- The small value of standard error for all samples indicated that how the average compressive strength was accurate.
- Further experimental studies are needed to understand the behaviour of Jersh row material of concrete such as coarse aggregate and fine aggregate.

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