Research Article

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# Construction of Concrete Paving Blocks using Industrial Wastes

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## ABSTRACT

An attempt has been made in this work to utilize industrial wastes (like fly ash) and plastic waste in concrete for the construction of concrete paving blocks by partial replacement of cement and coarse aggregate with water-cement ratios of 0.55 and 0.6. The concrete paving blocks were constructed with the nominal mix of 1:2:4; the partial replacements of cement and coarse aggregates were 15% and 5% with fly ash and plastic waste, respectively. The research objectives were to determine the compressive strength, flexure strength and split tensile strength of the concrete paving blocks. Specimens were tested for a duration of 7, 14 and 28 days. The study shows that cement can partially be replaced with fly ash and coarse aggregate can partially be replaced with plastic waste. The biggest advantage of the utilization of fly ash and plastic waste in the concrete paving block can reduce its wastage; the disposal of these materials in open land renders it affected. The utilization of industrial waste materials in concrete will aid in the reduction of environmental pollution. The results of the investigation have shown that for 0.55 water-cement ratio, the mechanical properties of concrete specimens were almost the same after 28 days duration.

**Keywords:** Fly ash; Mechanical strength; Plastic waste.

## 1. INTRODUCTION

Industrial waste materials like fly ash and plastic waste are hazardous and environmental pollution is increasing due to the daily production of these materials. Nowadays, the production of cement cannot be restricted due to the increasing demand in construction. Production of cement results in the emission of $CO_2$. An attempt has been made in this research work to utilize industrial wastes like fly ash and plastic waste in concrete for the construction of the paving block. Mostly these materials are disposed of on the open ground, resulting in environmental pollution and land-related problems. Moreover, the particles of fly ash mix with air, causing health issues. Plastic waste and fly ash deposited in surrounding water bodies are becoming big problems for living creatures. For the safety of health, life cycle and environment, monitoring and maximum utilization of these materials are required.

Pavement blocks are the perfect solution on the pathway and streets for simple laying and finishing. The aim of this research is to partially replace cement and coarse aggregate with fly ash and plastic waste. Results were compared with the referral concrete specimens to check the compressive, split tensile and flexural strengths with the water-cement ratios of 0.55 and 0.60. A nominal mix of 1:2:4 was considered using a methodology based on IS 10262:2009 for specimen construction. Ahirrao *et al.* (2013) investigated the pavement blocks made by replacing 25% of fly ash against cement, with 0.35% admixture by weight of cement and it has shown the best strength among the concrete pavement blocks containing other waste. Tapkire and Patil (2014) observed that using recycled plastic as aggregate in concrete is satisfactory. Utilization of the 20% recycled plastic aggregate in concrete does not influence the properties of cement. Nivetha *et al.* (2016) observed that the production of plastic paver blocks from solid waste (quarry dust, fly ash and PET) was productive. Plastic waste was carried to melt and mixed with a varying proportion of solid waste fly ash and quarry dust (PET 25-35%, fly ash 25% and quarry dust 40-45% in weight) gave more strength when compared with all other proportions and concluded that solid waste could be used as a main constitution for the preparation of paver block with the increased strength.

## 2. MATERIALS AND METHODOLOGY

In this experimental research, 15% of cement is partially replaced with fly ash and 5% of crushed plastic waste to aggregate. To examine the results, 36 cubes, 24 cylinders and 24 beams were prepared in the laboratory with water-cement ratios of 0.55 and 0.60, and the specimens were tested at the end of the 7, 14 and 28 days of curing. For the whole experimental design, PPC cement of prism brand was used. Locally available river sand was taken; fly ash and gypsum were also added in the mix of the specimen. Mixing has been done using a nominal mix of 1:2:4. 84 specimens were cast to determine the compressive strength, split tensile strength and flexural strength at 7, 14, and 28 days. Test data for the material: Cement = PPC (Portland pozzolana cement), specific gravity of cement = 2.6, specific gravity of coarse aggregate = 2.75, specific gravity of fine aggregate = 2.66, water absorption of coarse aggregate = 0.5%, water absorption of fine aggregate = 1%.

## 3. RESULTS AND DISCUSSION

Fly ash and plastic waste together were one of the biggest environmental problems in the current age. Since its disposal in open land is harmful, its utilization is also contained on a short scale. This study explores one of the applications of fly ash as well as plastic waste in addition to concrete in construction. The laboratory results obtained are discussed below:

**Table 1. Compressive strength of cubes at w/c = 0.55**

| S. No. | Cube designation | Compressive strength (N/mm)$^2$ | | | % of fly ash | % of plastic waste | w/c ratio | Avg. wt. of the cube specimen (N) |
|---|---|---|---|---|---|---|---|---|
| | | 7 days | 14 days | 28 days | | | | |
| 1 | V1 | 8.5 | 12.5 | 20 | 0 | 0 | 0.55 | 24 |
| 2 | V2 | 10 | 11.5 | 20 | 15 | 5 | 0.55 | 23.5 |

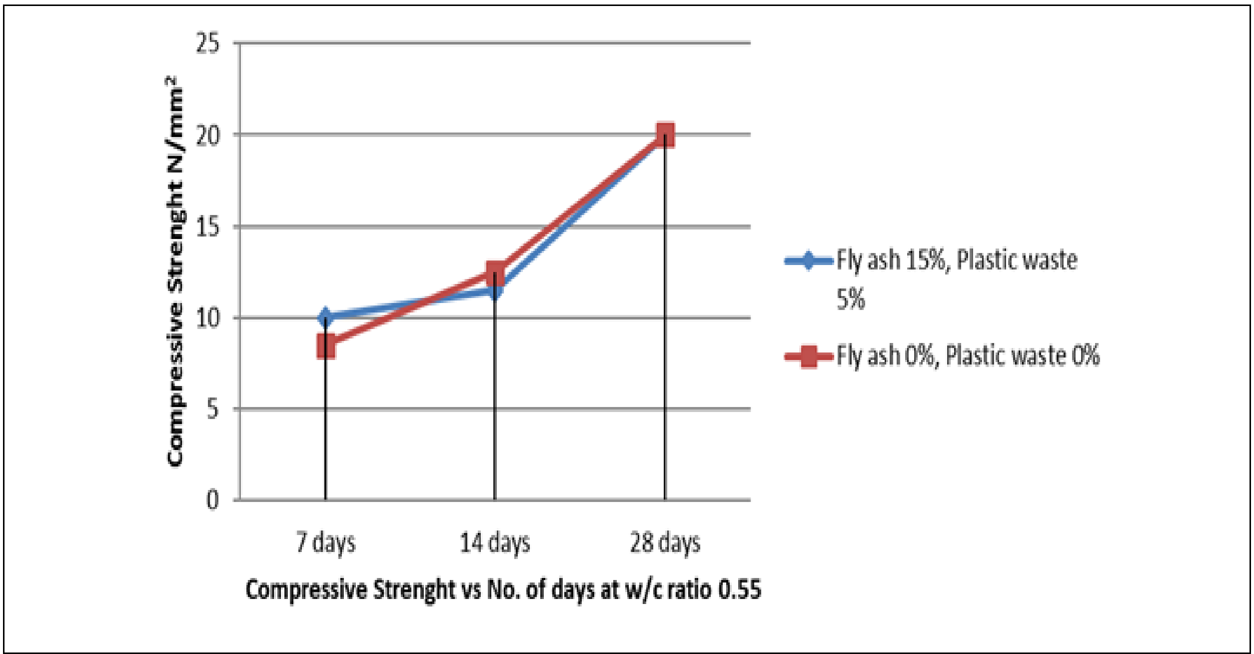


**Fig. 1: Compressive strength *vs.* No. of days at w/c = 0.55**

**Table 2. Compressive strength of concrete at w/c = 0.6**

| S. No. | Cube designation | Compressive strength (N/mm)$^2$ | | | % of fly ash | % of plastic waste | w/c ratio | Avg. wt. of the cube specimen (N) |
|---|---|---|---|---|---|---|---|---|
| | | 7 days | 14 days | 28 days | | | | |
| 1 | V1 | 8.0 | 12.5 | 19.0 | 0 | 0 | 0.6 | 2.4 |
| 2 | V2 | 10 | 10.5 | 18.0 | 15 | 5 | 0.6 | 2.4 |

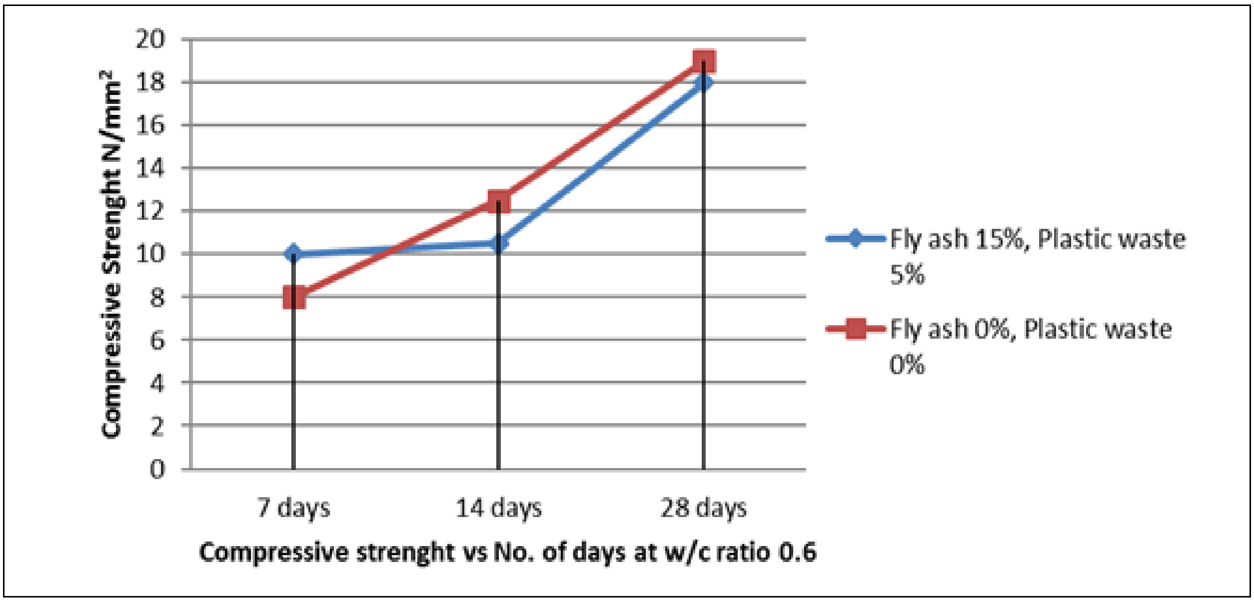


**Fig. 2: Compressive strength *vs.* No. of days at w/c = 0.6**

Compressive strength results were obtained for the referral mix and the specimens. No variation in strength is found (20 MPa) at 28 days for a water-cement ratio of 0.55 and variation in strength is found to be 19 to 18 MPa at 28 days for a water-cement ratio of 0.6. Test results have indicated that the compressive strength remained the same after the addition of fly ash and plastic waste for the water-cement ratio of 0.55. But for 0.6 w/c ratio, compressive strength was found to be lesser.

**Table 3. Split tensile strength of concrete (w/c = 0.55)**

| S. No. | Cylinder designation | Split tensile strength ($N/mm^2$) | | | % of Fly ash | % age of Plastic Waste | w/c Ratio | Avg. wt. of the cylindrical specimen (N) |
|---|---|---|---|---|---|---|---|---|
| | | 7 days | 14 days | 28 days | | | | |
| 1 | C1 | 4.5 | 8.0 | 10.0 | 0 | 0 | 0.55 | 6.35 |
| 2 | C2 | | 5 | 10.0 | 15 | 05 | 0.55 | 6.5 |

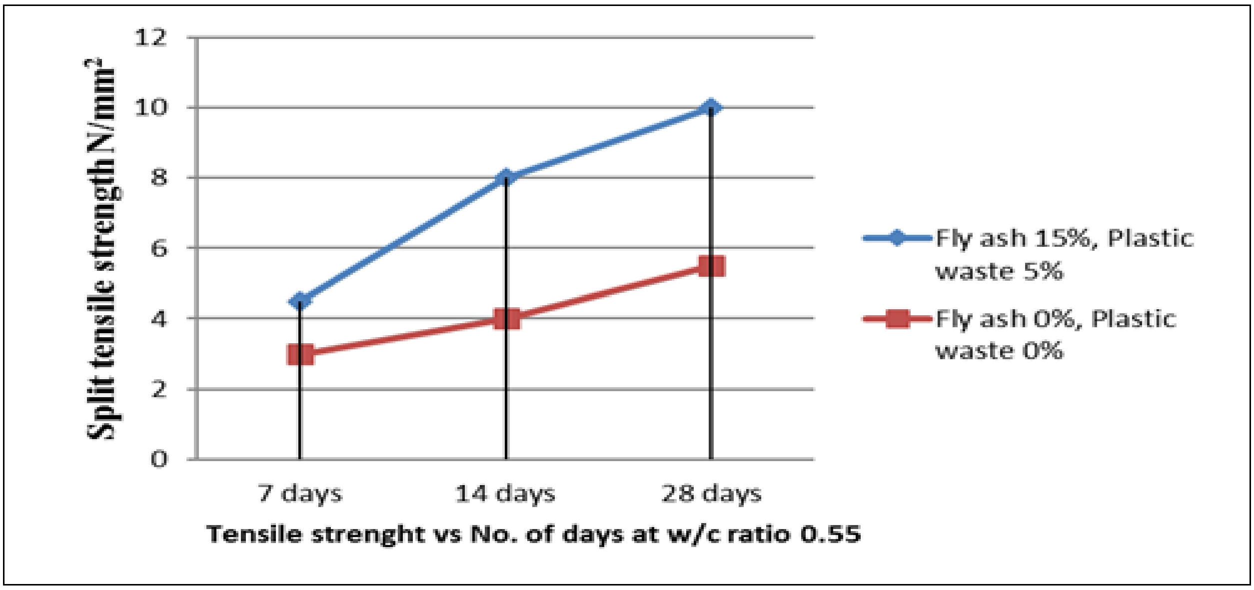


**Fig. 3: Tensile strength *vs.* No. of days (w/c = 0.55)**

**Table 4. Split tensile strength of concrete (w/c = 0.6)**

| S. No. | Cylinder designation | Split tensile strength (N/mm$^2$) | | | % of fly ash | % of plastic waste | w/c ratio | Avg. wt. of the cylindrical specimen (kN) |
|---|---|---|---|---|---|---|---|---|
| | | 7 days | 14 days | 28 days | | | | |
| 1. | C1 | 4.5 | 5.75 | 10.0 | 0 | 0 | 0.6 | 6.65 |
| 2. | C2 | 3.25 | 4.25 | 8.5 | 15 | 5 | 0.6 | 6.7 |

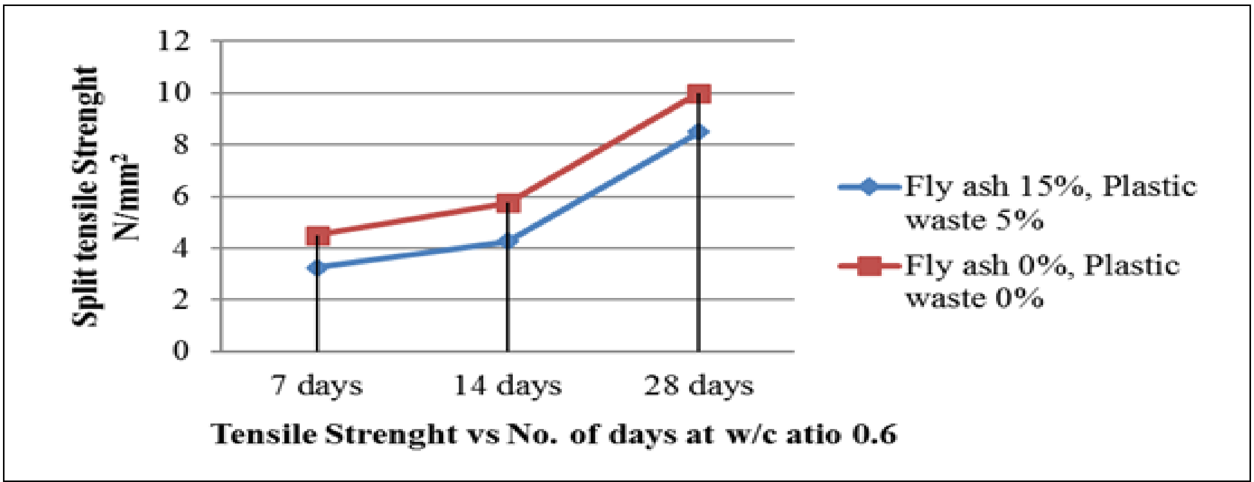


**Fig. 4: Tensile strength *vs.* No. of days (w/c = 0.6)**

Split tensile strength of concrete has no variation (10 MPa) at 28 days for the water-cement ratio of 0.55 and varies from 10 to 8.5 MPa at 28 days for the water-cement ratio of 0.6. Similar behavior was found in split-tensile testing. Overall, the experimental results have shown that industrial wastes like fly ash and plastic waste can be utilized as replacements for concrete.

**Table 5. Flexural strength of concrete (w/c = 0.55)**

| S. No. | Beam designation | Flexural strength (N/mm$^2$) | | | % of Fly ash | % of Plastic Waste | w/c Ratio |
|---|---|---|---|---|---|---|---|
| | | 7 days | 14 days | 28 days | | | |
| 1 | B1 | 6 | 7 | 7.75 | 0 | 0 | 0.55 |
| 2 | B2 | 6 | 6 | 7.0 | 15 | 05 | 0.55 |

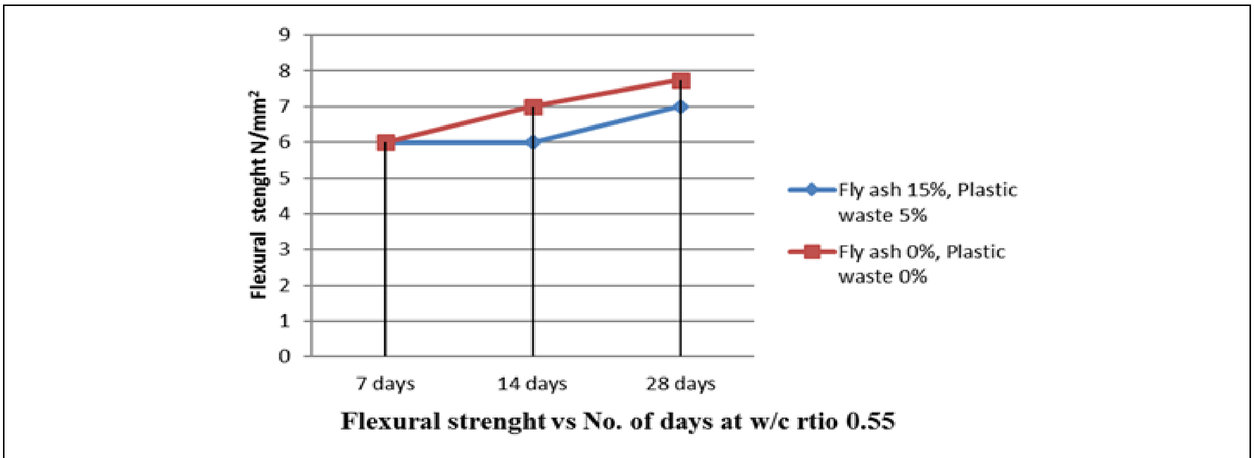


**Fig. 5: Flexural strength *vs.* No. of days (w/c = 0.55)**

**Table 6. Flexural strength of concrete (w/c = 0.6)**

| S. No. | Beam designation | Flexural strength (N/mm$^2$) | | | % of Fly ash | % of Plastic Waste | w/c Ratio |
|---|---|---|---|---|---|---|---|
| | | 7 days | 14 days | 28 days | | | |
| 1 | B1 | 5.5 | 6.5 | 7.0 | 0 | 0 | 0.60 |
| 2 | B2 | 4.0 | 5.5 | 6.0 | 15 | 5 | 0.60 |

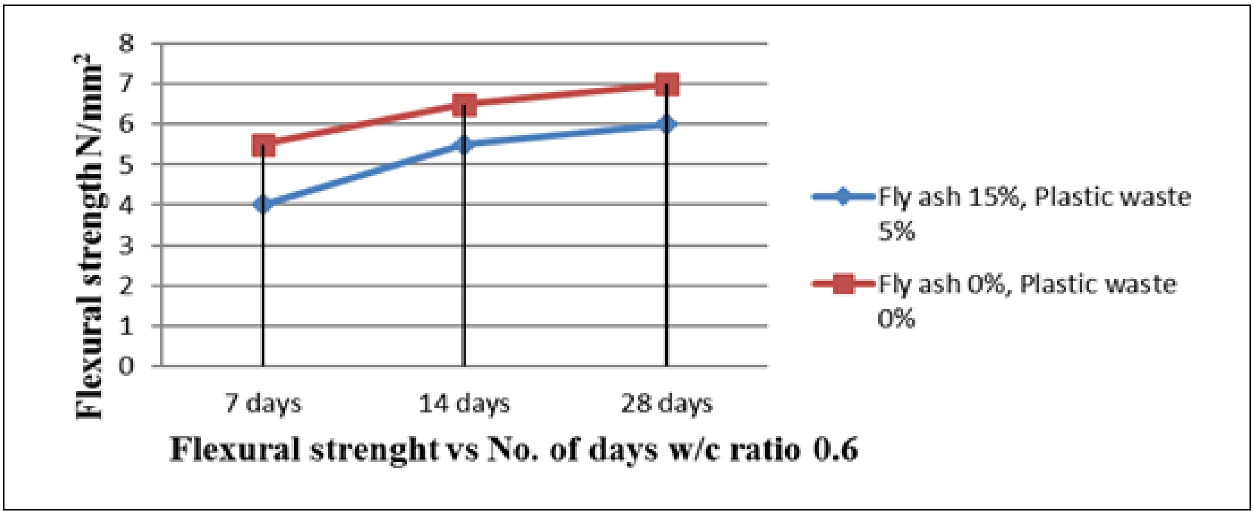


**Fig. 6: Flexural strength *vs.* No. of days (w/c = 0.6)**

Flexural strength of concrete varies from 7.5 to 7 MPa at 28 days for w/c = 0.55 and 7 to 6 MPa at 28 days for w/c =0.6. Similar behavior was found in flexural testing like compressive strength and split-tensile strength.

## 4. CONCLUSION

According to the experimental study and the results obtained, it can be concluded that by partially replacing cement and coarse aggregate with fly ash and plastic waste with different water-cement ratios, the compressive, tensile and flexural strengths of concrete specimens remained almost the same. In 0.55 water-cement ratio, strength enhancement was the same in all ages but more than the strength gain of 0.6 water-cement ratios. Based on the results, for paver concrete blocks, fly ash and the plastic waste combination can effectively be used in concrete; moreover, maximum consumption of these waste materials in concrete is the best possible way to reduce health safety issues and environmental pollution and water pollution due to their harmful effect.

### Future recommendation

The potential applications of fly ash and plastic waste-based concrete can be investigated as per the requirement of the market. Their advantages in concrete can further be examined in the laboratory as building materials. Maximum utilization of these materials in concrete as a building material is the best way to address environmental pollution challenges, dust problems, water pollution and open land encroachment issues. Plastic waste and fly ash deposited in surrounding water bodies are posing major problems for the biosphere. For safety, health and environmental protection, further efforts shall be taken by the researchers in the future.

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## CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

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