

Effect of Aluminium Waste Powder on the Strength Properties of Cement Mortar

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Abstract

The cement is used as primary binding material in the field of civil engineering is undoubtedly at a higher level due to the increase in urbanization. Concrete, cement mortar, and other composite building materials are made from it. The substantial use of OPC in the field of construction industry has increased the production of CO₂. This has huge negative impact on the environment and has encouraged everyone to explore and analyze practical advancement by substituting alternative waste products in concrete and mortar. Therefore, the objective of this study was to evaluate the strength performance of cement mortar containing Aluminium waste powder as a Cementitious Material. In this study, we have substituted the cement with different percentages i.e., 2.5% to 10% of Aluminium waste powder to obtain feasible mortar mix. The cubes of 50 mm size were cured for 3, 7, and 28 days, the properties of flowability, density, and compressive strength was studied. The results indicated that by increase in addition of Aluminum waste powder (AWP) flowability of mortar paste decreased, the water cement ratio was fixed as 0.50 for all type of mixes. The results indicated that the Density and Compressive Strength of Cubes cured in water, it was observed that as the % Addition of AWP increased the density and compressive strength of cubes cured were reduced. For Compressive Strength, it was found that at each designated day, the compressive strength of cubes up to 2.5% addition has given suitable value but intensely decreased at 10% addition. At 2.5% Addition Aluminium waste powder on 28th day test it was noticed that it has greater value of compressive strength for all % of addition.

Keywords:

Cement mortar, Aluminium waste powder, of flowability, compressive strength.

1. Introduction

Mortar is a viable paste that hardens to bind building blocks and seal the irregular gaps between them; it is glue that holds the wall system together. It is 7% of total volume of masonry wall but still, it plays an important role in structure performance because it conjointly seals the building against the wetness and air penetration (Hyder et al. 2021). When Cement mortar cures, it become hard, resulting in an inflexible aggregate structure; nevertheless, the mortar acts as a fragile element than the building blocks. Mortar is less expensive and easy to repair than the building blocks (Frías, Villar, and Savastano 2011). When the materials are freshly mixed, mortars have a plastic consistency which could be effortlessly worked with trowels to fill in the gaps in masonry or to even the surface of wall by plastering (Kuziak et al. 2021).

Aluminium is one of the widely used advancement material. It forms a subsidiary waste material by process of cutting and making of aluminium windows frames etc. However, this waste is dangerous and threat for the environment, from the biological point of view it is very important to utilize this waste (Kanadasan and Razak 2015). During manufacturing process, the Aluminium scarp is generated in many steps and is brought in use by consumer. The aluminium is lost during the production either at the melting stage where it becomes dross or during the machining operation applied to aluminium, every year, more than one million tonnes of aluminium packaging and containers (such as soda cans, TV dinner platters, and foil) are discarded (GÜLMEZ 2021).

Now-a-days researchers are intended in recycling and reusing of waste materials in the concrete (GÜLMEZ 2021). Additionally, firms engaged in the refining of aluminium produce unique strong wastes. Transfer and reuse of aluminium dissolving is a problem on a general level. A comprehensive literature review has been carried out on the utilization of Aluminium Waste powder (AWP) in the cement mortar. It was reported by Ajmal paktiwal and Mehtab alam (Paktiawal and Alam 2021) that the effects of using LDPE as an additional mass at different cement weight percentages of 3.5, 7, 12.5, and 21% on concrete with aluminium waste were investigated. Both freshly laid concrete and hardened concrete were evaluated. Concrete was examined for workability and expansion in its uncured form. The concrete underwent different strength, non-destructive, and durability testing after it had solidified. Based on the findings for 28 days, it can be concluded that the strength and workability of cement produced by using replaced aluminium waste with LDPE as an additive waste were significantly reduced.

Furthermore, stated that the aluminium dross can be added to concrete to increase its corrosion resistance within a range of parameters. Cement has been replaced by 5%, 10%, and 15% by weight of aluminium dross. Then concrete cubes are cast using this concrete. The compressive strength of the cast cubes is measured over a period of 7, 15, and 28 days (Amar et al. 2018). Another study was also considered the addition of aluminium in mortar and evaluates the mechanical functionality of mortars subjected to freeze-thaw cycles. In this study, the density, compressive strength, and workability characteristics of mortar mixtures with various amounts (0%, 5%, and 7.5%, by weight of cement) of aluminium by-product were assessed. The impact of freezing and thawing on the mechanical characteristics of aluminium waste mortar materials (MC, M5 and M7.5) were examined. The test results showed that with addition of Al the workability, mechanical resistance, density considerably decreased. The results also demonstrated that where light and low-strength mortar is required aluminium based mortar paste may be adequate. Overall, the study's findings show that employing AL to make low strength concrete is feasible and can contribute to building sustainable structures (Tebbal and Rahmouni 2019). However, the stability of radioactive organic effluents in cementitious matrices was optimized. The effects of alumina powder addition on the physical, chemical, and mechanical characteristics of cement paste were observed. Portland cement, sand, water, and alumina powder (88 μ m) were mixed to create the mortar. According to the study, adding 12% alumina powder increases compressive strength (Moutei et al. 2018).

2. Materials And Methodology

The Ordinary Portland Cement (OPC) was used as main binding material in the mortar. It is a binding material that holds and sticks the rest of the constituents firmly together in a homogeneous form. The OPC brand of lucky cement was taken from locally market Khairpur mir's. The fine aggregate used in this study were collected called Bolari sand available in the laboratory. Aluminium Waste Powder (AWP) was taken from the Aluminium factory in Sukkur and passed from #50 (300 micron) as shown in Fig.1. AWP was added in the mortar mix with reference to the weight of cement, different percentage like 2.5%, 5%, 7.5% and 10% was added in the mortar.



Before sieving



After Sieving

Figure. 1. Aluminium Waste Powder Before and After Sieving

The mix ratio for the preparation of mortar was selected as 1:3 (cement to fine aggregate) with water to cement ratio of 0.50. Total 45 cubes of size 50mm \times 50mm \times 50mm were prepared through moulds. The AWP was added as 0%, 5%, 7.5%, 10% and 15% with reference to weight of cement. The de-moulding was done after 24 hours then samples were kept in curing of 36 cubes has been done in plain water for 3, 7 and 28 days. However, three samples for each mix proportion were tested at 3day, 7day and 28day. The fresh mortar mix was initially tested for the flowability test and after the hardening the samples were tested for density and compressive strength at the age of 3, 7 and 28days.

3.Results And Discussion

3.1. Flowability

To observe the flowability of cement mortar, Flow Table test was performed on fresh mortar paste at different percentages of AWP as addition in the mortar mix. Results were obtained and presented in Fig. 2. Results indicated that the flowability of mortar paste is decreasing with the rise in addition of AWP at 2.5%, 5%, 7.5% and 10% and as we have fixed the w/c ratio for all type of mix i.e., 0.50, it declared that AWP absorbed more water. It was observed that as the AWP amount increased the water demand of the mortar mix was also increased.

Therefore, if the same workability is needed, the water to cement (w/c) ratio should be gradually raised. Alternatively, one can add various admixtures, such as plasticizers or super plasticizers, to retain the necessary strength with the needed workability. It was noted that the amount of water needed by the mortar mix increased when AWP is added.

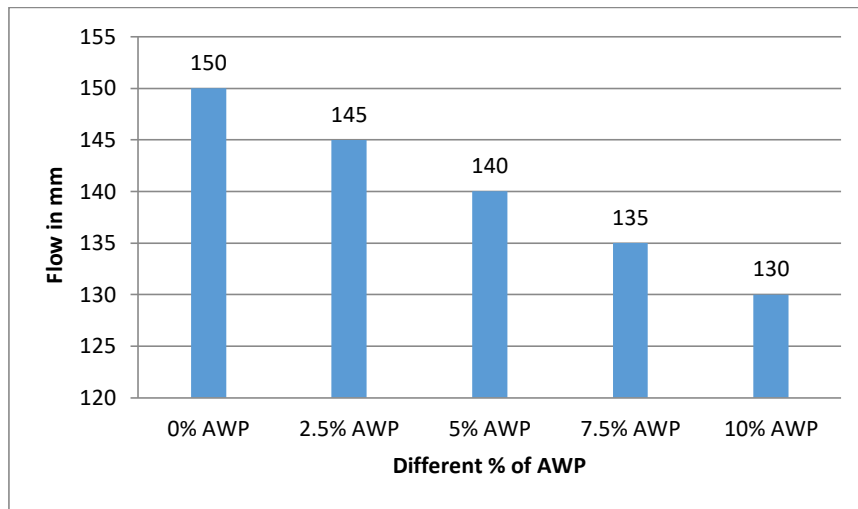


Figure. 2. Flowability results with different proportions of AWP

3.2. Density

After curing at 3, 7 and 28 days, the density of mortar cubes were found by calculating the weight and volume as the results are mentioned in the Fig. 3. It was observed from the experimental findings that the as the addition of AWP increased the density of mortar was also increased. However, it was also noticed that the density of mortar containing AWP was declined as compared to the control mix, which indicates that addition of AWP can produce light weight mortar, it is due to the lower specific gravities values than the OPC cement (Haris 2016).

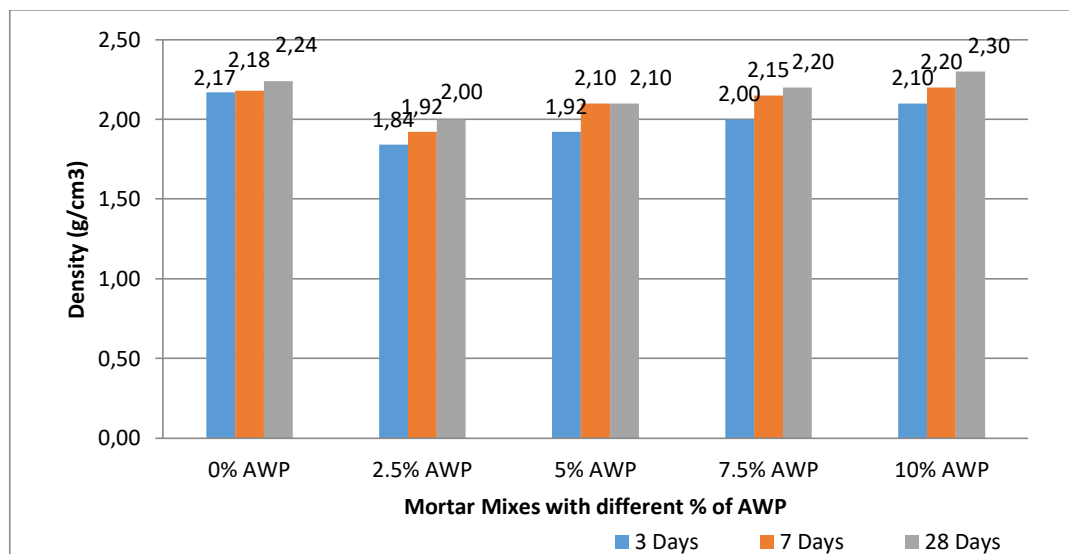


Fig. 3. Density of hardened mortar with different proportions of AWP

3.3. Compressive Strength

The test was carried out through compressive testing machine as shown in Fig. 4 by testing total of 45 cubes. This test was done by testing 3 cubes at different proportions of cement with addition of AWP at 3, 7 and 28 days cured in plain water. The values gained from the compressive strength tests at different proportions after designated curing periods i.e., 3days, 7days, 28days are presented in Fig. 4. Results demonstrated that compressive strength of mortar containing AWP was reduced as compared with the control mix. The results obtained from the tests performed in the laboratory indicated that the addition of AWP in cement mortar decreased the compressive strength of cement mortar. However, the strength was increased at 28days as compared to the 3days and 7days curing period. The mortar mix at the early age of 3days gained lower strength (Moutei et al. 2018) as compared to the 7 days and 28days of curing. Based on the experimental findings 2.5% is considered as optimum dosage of

AWP in mortar mix which gives lowest reduction around 22% in compressive strength as compared to the control mix at the age of 28days.

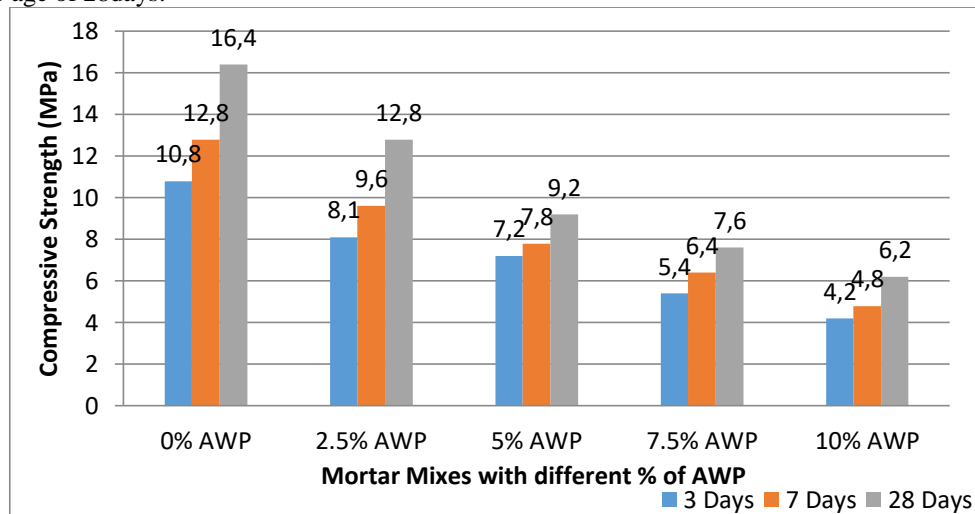


Figure. 4. Compressive strength of hardened mortar with different proportions of AWP at different ages

4. Conclusion & Suggestion

Following conclusions can be drawn:

1. Flowability decreases from 3% to 13% by adding 2.5% to 10% AWP.
2. The addition of AWP decreases the density of mortar around 10% as compared to the control mix, which indicates that the addition of AWP can produce light weight mortar.
3. Based on the experimental findings 2.5% is considered as the optimum dosage of AWP in mortar mix which gives lowest reduction around 22% in compressive strength as compared to the control mix at the age of 28days.

This study recommended that the future studies may consider the finest particle size of AWP, the curing period may be considered more than the 28days, the different w/c ratios may be considered in the future studies and the addition percentage must be considered lower than the 2.5%.

5. Acknowledgement

The Authors of this research acknowledged the support of MUET, SZAB Campus Khairpur Mir's.

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