

Sustainable Utilization of Apple Tree Pruning Waste Ash for the Production of M20 Concrete Bricks

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ABSTRACT: The increasing demand for cement and the environmental problems associated with agricultural waste disposal have encouraged the search for sustainable construction materials. Apple tree pruning waste is generated in large quantities in Jammu and Kashmir and is generally disposed of by open burning, causing environmental pollution. This study investigates the feasibility of utilizing Apple Tree Pruning Waste Ash (ATPWA) as a partial replacement of cement in M20 concrete bricks. Concrete bricks of size 9 in × 4 in × 3 in were cast with 0%, 10%, 15%, 20%, and 25% replacement of cement by ATPWA. Compressive strength tests were conducted at curing ages of 7, 14, 21, and 28 days. Experimental results demonstrated an increase in compressive strength up to a replacement level of 10%, beyond which the strength gradually decreased. The maximum 28-day compressive strength achieved was 26.99 MPa at 10% replacement compared with 23.59 MPa for conventional concrete bricks, representing an increase of approximately 14.4%. The study concludes that ATPWA can serve as an effective sustainable supplementary cementitious material while simultaneously reducing agricultural waste disposal problems.

KEYWORDS: Apple Tree Pruning Waste Ash, Sustainable Concrete, Concrete Bricks, Cement Replacement, Compressive Strength, Green Construction.

I. INTRODUCTION

The increasing demand for cement and the environmental problems associated with agricultural waste disposal have encouraged the search for sustainable construction materials. Apple tree pruning waste is generated in large quantities in Jammu and Kashmir and is generally disposed of by open burning, causing environmental pollution. This study investigates the feasibility of utilizing Apple Tree Pruning Waste Ash (ATPWA) as a partial replacement of cement in M20 concrete bricks. Concrete bricks of size 9 in × 4 in × 3 in were cast with 0%, 10%, 15%, 20%, and 25% replacement of cement by ATPWA. Compressive strength tests were conducted at curing ages of 7, 14, 21, and 28 days. Experimental results demonstrated an increase in compressive strength up to a replacement level of 10%, beyond which the strength gradually decreased. The maximum 28-day compressive strength achieved was 26.99 MPa at 10% replacement compared with 23.59 MPa for conventional concrete bricks, representing an increase of approximately 14.4%. The study concludes that ATPWA can serve as an effective sustainable supplementary cementitious material while simultaneously reducing agricultural waste disposal problems.

II. LITERATURE SURVEY

Numerous researchers have explored the use of agricultural and biomass waste materials in concrete production. Chowdhury et al. reported significant improvements in concrete properties through the incorporation of wood waste ash. Thomas et al. demonstrated that biomass ashes can effectively improve sustainability and reduce cement consumption. Siddika et al. showed that proper processing of agricultural waste ashes significantly influences the performance of concrete. Ercan et al. observed that controlled replacement levels of biomass ash can improve concrete properties while reducing environmental impacts.

Previous studies indicate that optimum replacement levels generally range between 5% and 15%, beyond which excessive ash content may adversely affect strength and workability. However, research concerning Apple Tree Pruning Waste Ash generated in Kashmir remains limited. This study addresses this gap.

III. METHODOLOGY

Collection of raw materials and apple tree pruning waste.
Preparation of ATPWA by controlled burning and sieving.
Design of M20 concrete mix with 0%, 10%, 15%, 20%, and 25% ATPWA replacement.
Casting of concrete bricks of size 9 in × 4 in × 3 in.
Water curing for 7, 14, 21, and 28 days.
Compressive strength testing and analysis of results.

IV. EXPERIMENTAL RESULTS

Compressive Strength Profile

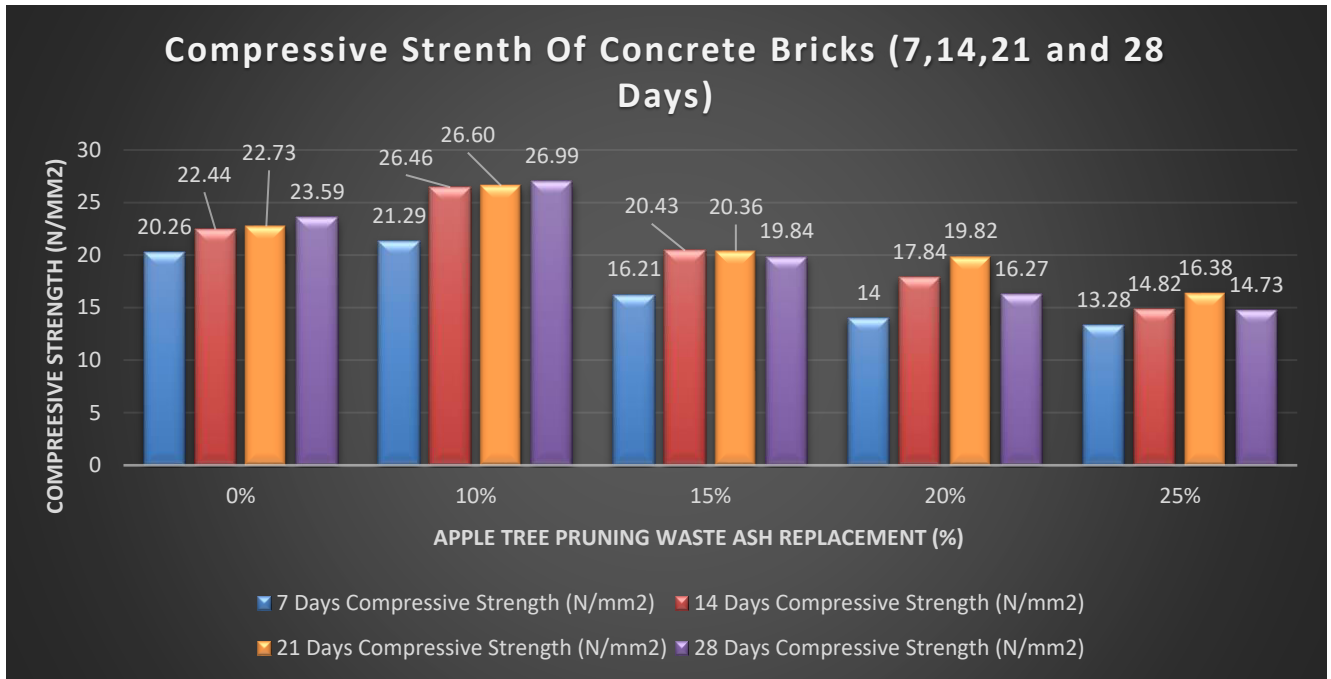
1. Baseline (0% Replacement): The control mix achieved an average 28-day compressive strength of 23.59 MPa.
2. Optimum Strength (10% Replacement): The 10% replacement level yielded the highest strength of 26.99 MPa, marking an improvement of approximately 14.4% over the control mix.
3. Degradation Phase (15% to 25% Replacement): At the 25% replacement level, compressive strength declined to 14.73 MPa, which is significantly lower than the control mix.

Mechanisms of Enhancement and Degradation

1. Reasons for Enhancement (up to 10%): The fine ash particles act as micro-fillers, reducing voids and improving the density of the cement matrix.
2. Reasons for Degradation (>10%): Higher replacement levels reduce the amount of cement available for hydration, resulting in insufficient formation of binding products and lower strength.
3. Workability Impacts: Workability decreased at higher replacement levels due to the high fineness and water demand of the ash particles.

Replacement (%)	7 Days Compressive Strength (N/mm ²)	14 Days Compressive Strength (N/mm ²)	21 Days Compressive Strength (N/mm ²)	28 Days Compressive Strength (N/mm ²)
0%	20.26	22.44	22.73	23.59
10%	21.29	26.46	26.60	26.99
15%	16.21	20.43	20.36	19.84
20%	14	17.84	19.82	16.27
25%	13.28	14.82	16.38	14.73

Compressive Strength at 7, 14, 21 and 28 Days



V. CONCLUSION

Apple Tree Pruning Waste Ash can successfully replace a portion of cement in concrete bricks. The optimum replacement level is 10%. The maximum 28-day compressive strength achieved was 26.99 MPa. Strength improvement of approximately 14.4% was observed. Sustainable utilization of apple tree pruning waste reduces environmental pollution and provides an eco-friendly alternative for concrete production.

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