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To Study the Mechanical Property of Concrete using Wall nut ash and Waste paper ash with Addition of Urea

[1]Qurat ul mushtaq, [2]Er Sourabh Lalotra

[1]Student, [2]Assistant professor, SSCET, Punjab Technical University, Punjab, India

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Abstract-*This study investigates the mechanical and durability properties of concrete containing Walnut Shell Ash (WSA) and Waste Paper Ash (WPA) as partial cement replacements, with addition of urea. Equal proportions of WSA and WPA were used to replace cement at various replacement levels, while urea was added at a constant dosage of 0.5 by weight of cement. The mechanical performance of concrete was evaluated through compressive strength, split tensile strength, and flexural strength tests. The experimental results revealed that concrete containing a total replacement of 12% (6% WSA + 6% WPA) with 3% urea exhibited the optimum mechanical performance, achieving higher strength values compared to other replacement levels. The findings indicate that the combined use of WSA, WPA, and urea can enhance concrete properties while promoting the sustainable utilization of agricultural and paper industry wastes, thereby reducing cement consumption and environmental impact.*

Keywords: Walnut Shell Ash (WSA), Waste Paper Ash (WPA), Urea, Compressive Strength, Split tensile , Workability, Water Absorption, Eco-friendly Construction, Waste Utilization.

I. INTRODUCTION

Concrete is one of the most widely used construction materials due to its strength, durability, and versatility. It is produced by combining cement, fine aggregate, coarse aggregate, and water, which harden into a solid mass. The incorporation of supplementary materials and admixtures can further enhance its mechanical and durability properties while promoting sustainable construction practices

Walnut Shell Ash (WSA) is an agricultural waste material obtained by the controlled burning of walnut shells. It contains significant amounts of silica and other mineral compounds that exhibit pozzolanic properties. The utilization of WSA as a partial cement replacement helps reduce environmental pollution and cement consumption. Its incorporation in concrete can improve sustainability while maintaining satisfactory Waste

Paper Ash (WPA) is a by-product obtained from the controlled burning of waste paper materials. It contains silica, calcium, and other mineral constituents that can contribute to the pozzolanic activity of concrete. The utilization of WPA as a partial replacement for cement helps in reducing waste disposal problems and conserving natural resources. Its use in concrete promotes sustainable construction while potentially improving certain engineering properties, mechanical and durability performance.

Urea is a nitrogen-based compound that has recently been explored as an additive in cementations materials. When added in small quantities, urea can influence the hydration process and modify the properties of concrete. Its incorporation may improve workability and contribute to strength development under certain conditions. Therefore, urea has gained attention as a potential admixture for enhancing the performance of concrete.

II. LITERATURE REVIEW

Darweesh (2025) investigated the use of Walnut Shell Ash (WSA) as a partial replacement for cement at replacement levels ranging from 5% to 25%. The study reported that concrete containing up to 15–20% WSA exhibited satisfactory mechanical properties, while higher replacement levels resulted in a reduction in strength. The improvement in performance was attributed to the pozzolanic activity of the ash and its filler effect within the cement matrix.

Kejela (2020) evaluated Waste Paper Ash (WPA) as a partial cement replacement at levels of 0%, 5%, 10%, 15%, and 20%. The results showed that concrete with 5–10% WPA achieved strength values comparable to conventional concrete. However, further increases in WPA content led to a gradual decrease in compressive strength due to the reduced cementations content.

Wang et al. (2020) studied the effect of urea addition on concrete by incorporating urea at dosages ranging from 1% to 5% by weight of cement. The researchers observed that lower dosages, particularly around 1–3%, positively influenced the hydration process and strength development, whereas higher dosages caused a reduction in mechanical performance. The study concluded that an optimum amount of urea can enhance concrete properties without adversely affecting durability.

III. MATERIALS

A. Cement

Ordinary Portland Cement (OPC) conforming to 43 grade specifications was employed as the main cementitious material in this investigation. This grade of cement exhibits satisfactory resistance to sulphate attack and develops moderate heat upon hydration. The cement was obtained from a nearby construction material dealer, and Khyber Cement was used throughout the study for concrete production.

Pic. No. 1 : cement

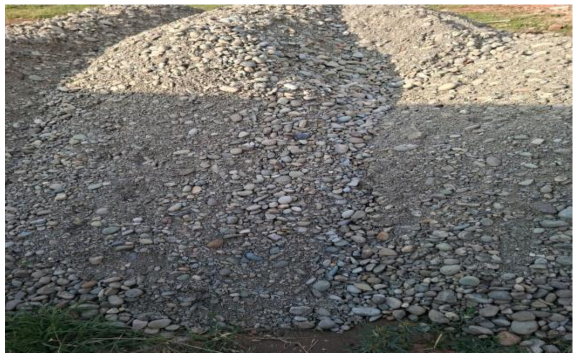
B. Fine Aggregate

Natural river sand passing through a 4.75 mm sieve was used as fine aggregate. It was clean and free from impurities. It helps fill voids between coarse aggregates and improves concrete workability. The properties of sand, including specific gravity, fineness modulus, and water absorption, were tested as per IS specifications.

Pic. No. 2 : Fine aggregate

C. Coarse Aggregate

Crushed stone of 20 mm nominal size was used as coarse aggregate. The aggregates were clean, hard, and durable, providing strength and stability to concrete. Tests such as specific gravity, water absorption, and impact value were conducted before use.



Pic. No. 3: Course aggregate

D. Walnut Shell Ash (WSA)

Walnut shells collected from the local village Kangan in District Ganderbal were cleaned, sun-dried, burned under controlled conditions, and sieved through a 300 µm sieve to obtain fine ash. This walnut shell ash (WSA) was used as a partial cement replacement due to its pozzolanic potential, thereby reducing cement consumption and aiding in the sustainable management of agricultural waste.

Table 1 : Properties of Walnut Shell Ash

Chemical Compound	Symbol	Typical Content (%)
Silicon Dioxide	SiO_2	25–45
Calcium Oxide	CaO	10–25
Aluminum Oxide	Al_2O_3	2–8
Ferric Oxide	Fe_2O_3	1–5
Magnesium Oxide	MgO	1–5
Potassium Oxide	K_2O	5–20
Sodium Oxide	Na_2O	0.1–2
Sulfur Trioxide	SO_3	<2
Loss on Ignition	LOI	5–20

E. Waste Paper Ash (WPA)

Waste paper was collected, dried, burned to produce ash, and sieved to obtain uniform fine particles. WPA, containing silica and other compounds, was used as a supplementary cementations material to enhance concrete properties through secondary hydration reactions.

Table. 2 : Properties of Waste paper Ash

Chemical Compound	Symbol	Typical Content (%)
Silicon Dioxide	SiO_2	45- 65
Calcium Oxide	CaO	10- 30
Aluminum Oxide	Al_2O_3	5-15
Ferric Oxide	Fe_2O_3	1-5
Magnesium Oxide	MgO	1-5
Potassium Oxide	K_2O	1-8
Sodium Oxide	Na_2O	0.5-3
Sulfur Trioxide	SO_3	<3
Loss on Ignition	LOI	2-15

F. Urea

Commercially available urea was added in controlled proportions based on cement weight. It was dissolved in mixing water before use to ensure uniform distribution and to modify the hydration and mechanical properties of concrete.

METHODOLOGY

A. Mixing Concrete

All the ingredients of concrete are thoroughly mixed in the required proportions to obtain a homogeneous mix with uniform color and consistency. Mixing is carried out either manually or using a mechanical mixer to ensure proper distribution of the materials.

B. Curing

Before testing, the specimens are kept in the moulds for 24 hours, then demoulded, marked for identification, and cured in a water tank. The specimens are removed after 3, 7, and 28 days of curing, surface-dried, and tested in the respective testing machine.

C. Workability

The workability of fresh concrete was determined using the slump cone test, which can be conducted both in the laboratory and at construction sites. The slump cone is a frustum-shaped mould having a top diameter of 10 cm, bottom diameter of 20 cm, and height of 30 cm. This test is suitable for concrete with medium workability and is not recommended for very low or very high workability mixes.

Concrete was placed in the slump cone in four equal layers, and each layer was compacted with 25 strokes of a standard tamping rod. The cone was then lifted vertically, and the slump of the concrete was measured to determine its workability.

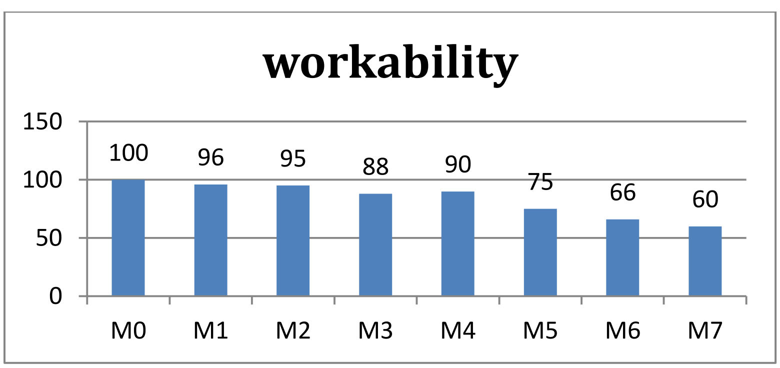


Fig. 1: Slump Cone

D. Compressive Strength Test

Fresh concrete is placed in moulds in four layers, and each layer is compacted with 35 strokes for cubes and 25 strokes for cylinders using a standard tamping rod. The top surface is leveled with a trowel, and after 24 hours the specimens are demoulded and cured in water at 27 ± 2°C. The specimens are tested after 7, 14, and 28 days of curing.

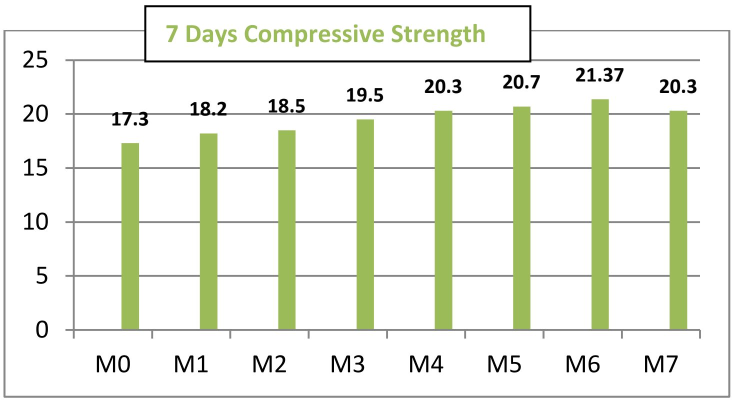


Fig. 2: compressive strength test 7

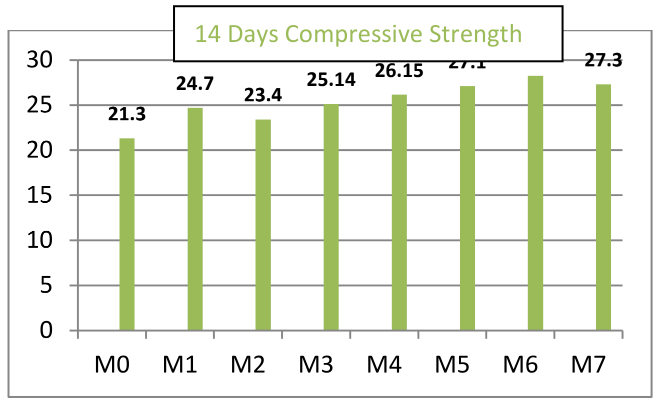


Fig. 3: compressive strength test 14

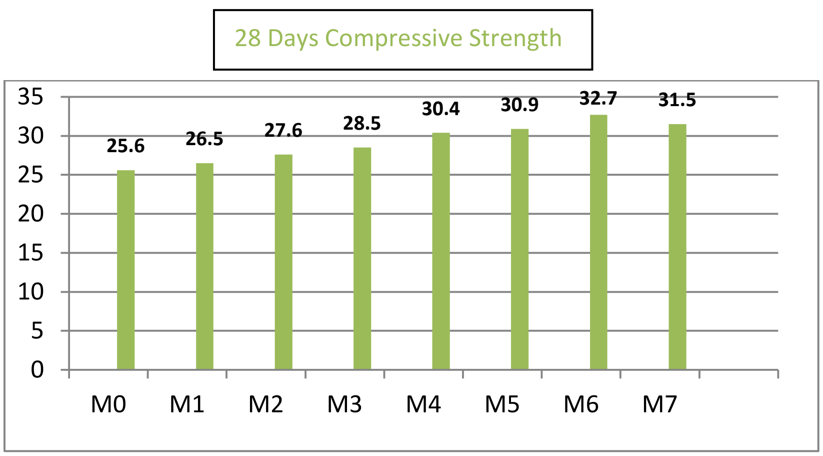


Fig. 4 : compressive strength test 28

E. Split Tensile Test

The split tensile strength test was performed on cylindrical specimens of 150 mm diameter and 300 mm height using a Universal Testing Machine (UTM). Fresh concrete was placed in moulds in layers and compacted with 25 blows per layer using a standard tamping rod. After 24 hours, the specimens were demoulded and cured in water at 27 ± 2°C for 7, 14, and 28 days. Before testing, diametrical lines were marked on the specimens, and the maximum load at failure was recorded to determine the split tensile strength.

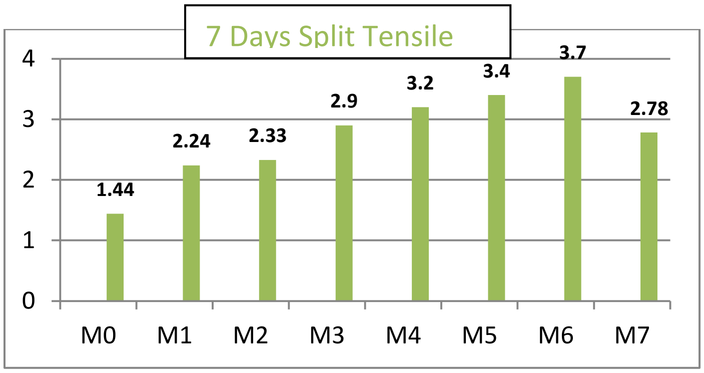


Fig. 5: split tensile test 7

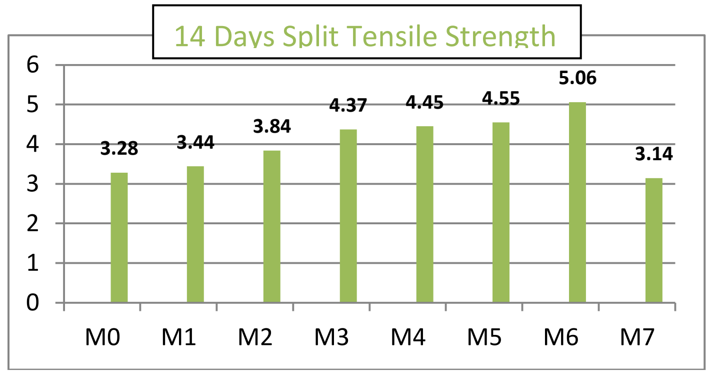


Fig. 6 : split tensile test 14

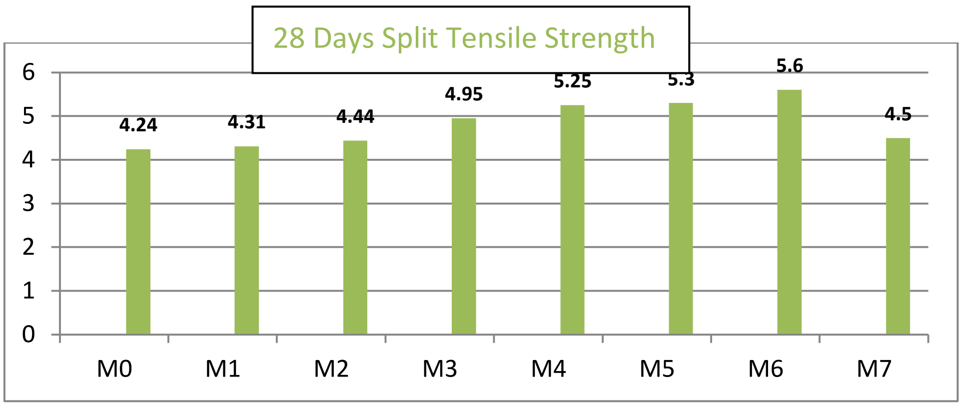


Fig. 7 : split tensile test

F. Flexural Strength Test

Concrete was cast in beam moulds according to the required mix proportions and compacted with 25 strokes of a standard tamping rod for each layer. After 24 hours, the specimens were demoulded and cured in water at 27 ± 2°C for 7, 14, and 28 days. Before testing, the specimens were removed from the curing tank, wiped dry, and tested for flexural strength

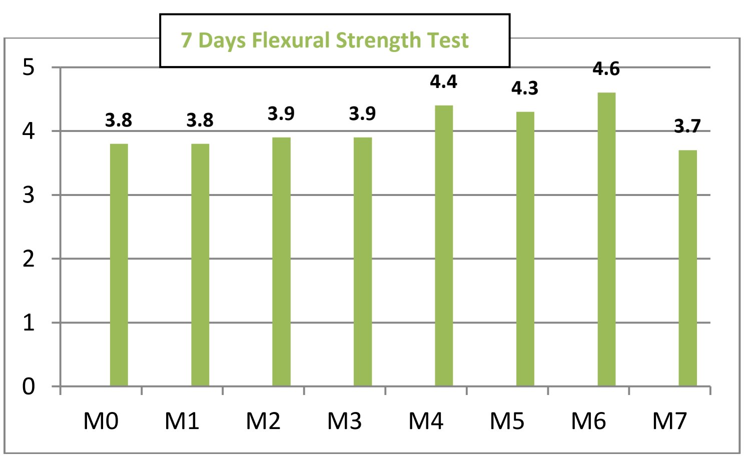


Fig. 8 : flexural strength test 7

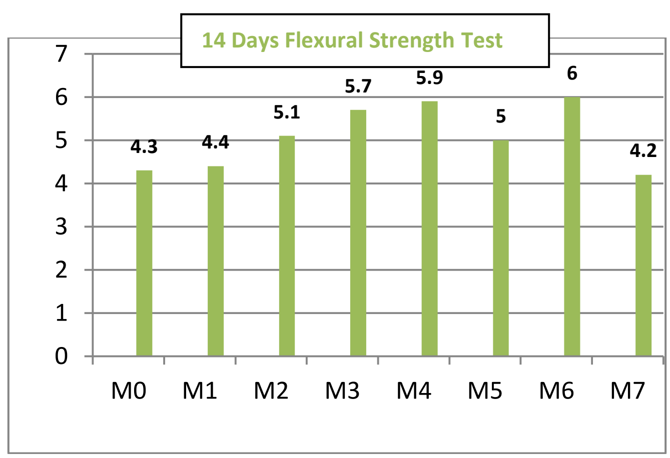


Fig. 9 : flexural strength test 14

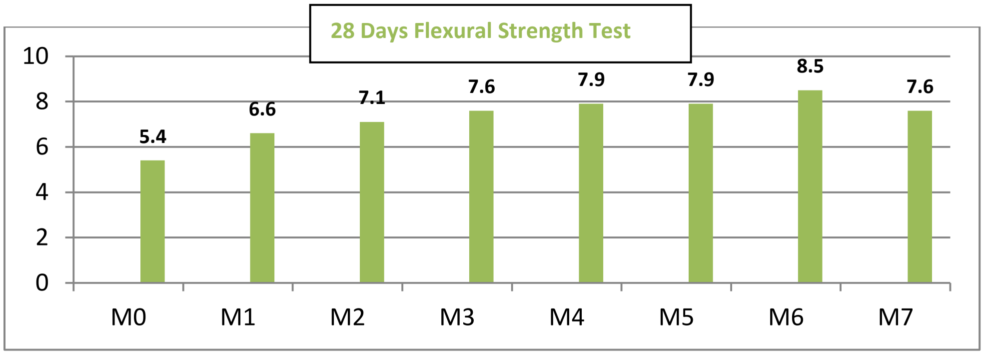


Fig. 10 : flexural strength test 28

G. Water Absorption Test

Concrete specimens are cured for the required period and then dried in an oven until a constant weight is obtained. The dried specimens are immersed in water for 24 hours, after which they are removed, surface-dried, and weighed to determine the percentage of water absorbed

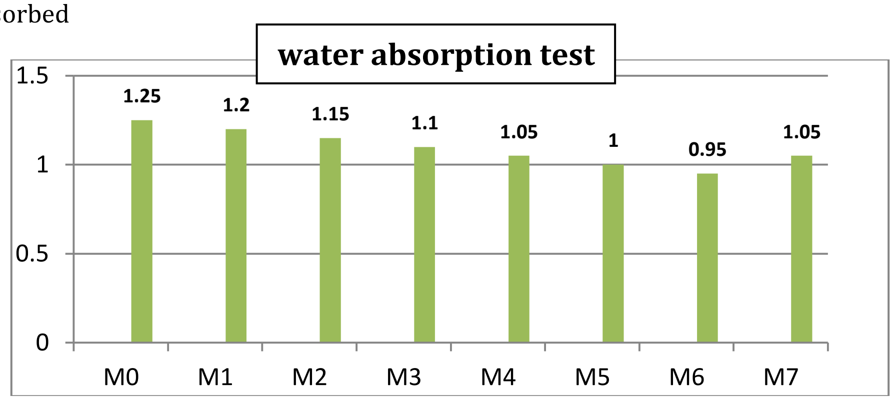


Fig. 11 : water absorption test

H. Sulphate Attack Test

Concrete specimens are cured for 28 days and then immersed in a sulphate solution. After the specified exposure period, the specimens are removed, surface-dried, and tested to evaluate the effect of sulphate attack on concrete strength and durability.

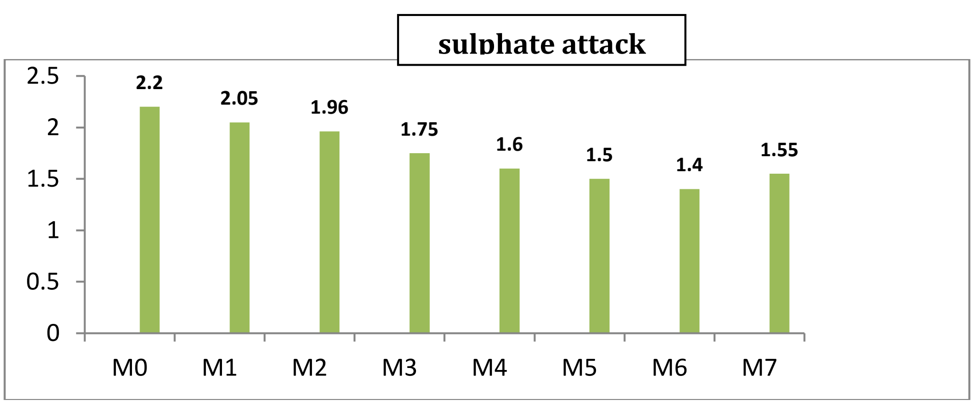


Fig. 12 : sulphate attack test

CONCLUSION

This study investigates the effect of replacing cement with Walnut Shell Ash (WSA) and Waste Paper Ash (WPA), along with the addition of 3% urea, on the mechanical and durability properties of concrete. The results indicate that the strength and workability of concrete improve up to an optimum replacement level, after which a reduction in performance is observed. The compressive strength of concrete compared to conventional concrete shows optimum performance at 12% replacement of cement with equal proportions of WSA and WPA along with 3% urea addition, with a maximum compressive strength of 28.23 N/mm^2 at 28 days of curing. Similarly, the flexural strength also reaches its highest value at the same optimum mix, with a maximum flexural strength of 8.5 N/mm^2 at 28 days. The split tensile strength of concrete is also enhanced, achieving a maximum value of 5.6 N/mm^2 at 28 days of curing for the same mix proportion. In terms of durability, the water absorption was found to be minimum at the optimum mix of 12% WSA and WPA replacement with 3% urea addition, indicating improved densification and reduced porosity of the concrete matrix. Overall, the study concludes that the optimum mix significantly enhances the mechanical strength and durability characteristics of concrete compared to conventional concrete.

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