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Original Article

Utilization of Pistachio Shell Powder as Partial Replacement of Cement in Concrete

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Abstract: *This study investigates the use of pistachio shell powder (PSP) as a sustainable partial replacement for cement in M25 and M40 grade concrete. PSP was used to replace cement at 0%, 10%, 20%, 30%, and 40% levels. Concrete specimens were tested for workability, compressive strength at 7 and 28 days, and water absorption. Results indicate that up to 10–20% replacement provides acceptable strength with environmental benefits. Beyond this level, strength decreases significantly due to reduced cementitious properties. The study concludes that PSP can be effectively used as a partial eco-friendly binder in concrete.*

Keywords: *Pistachio shell powder, M25 concrete, M40 concrete, Sustainable materials, Cement replacement*.

I. INTRODUCTION

Concrete is the most widely used construction material in the world, primarily composed of cement, aggregates, and water. However, cement production contributes significantly to carbon dioxide emissions, leading to environmental concerns. To address this issue, researchers have focused on alternative materials, particularly agricultural wastes, to partially replace cement. Pistachio shells are a by-product of the food industry and are often discarded as waste. These shells possess fibrous and porous characteristics, making them a potential candidate for use in construction materials. Utilizing pistachio shell powder in concrete not only reduces waste disposal problems but also minimizes cement consumption, contributing to sustainable development. This study aims to investigate the mechanical and durability properties of concrete when cement is partially replaced with pistachio shell powder in varying proportions.

II. LITERATURE REVIEW

Mahmut Durmaz et al., (2025) The experimental results demonstrate that PSA substitution significantly influences the compressive strength development of cement mortars. At early curing stages (1, 7, and 28 days), mortars containing 5% PSA exhibited enhanced strength characteristics compared to the control mixture, with measured values of 21.8 MPa, 33.1 MPa, and 41.0 MPa, respectively, versus 17.8 MPa, 28.9 MPa, and 39.2 MPa for the plain mortar.

Imad Manssouri et al., (2025) In summary, this study evaluated the performance of unfired earth bricks reinforced with recycled pistachio shells. Both experimental and theoretical analyses highlighted the high efficiency of this additive in producing bricks that comply with local and international construction standards. Moreover, the results demonstrated that these bricks are competitive with industrial alternatives available on the market

İ. Tekin et al., (2021) The pistachio shell ash (PSA) was used as a supplementary cementitious material (SCM). The presence of graphitic structures in PSA contributed to the early strength properties of cement.10% PSA incorporation improved the compressive strength value of cement by 17% at 400 days. The 28 days and the later age strength values were found to be satisfactory at even 20% PSA.The use of PSA is strictly recommended for sustainability goals of the cement industry.

III. MATERIALS AND METHODS

A. Materials

- Cement: OPC 53 Grade
- Fine Aggregate: M-Sand
- Coarse Aggregate: 20 mm crushed stone
- Water: Potable water
- PSP: Ground pistachio shell powder

a) Cement

Ordinary Portland Cement (OPC 53 grade) was used as the primary binding material in this study. Cement plays a vital role in concrete as it reacts with water through the hydration process to form a strong binding paste. This paste binds the fine and coarse aggregates together to form a solid mass. OPC 53 grade was selected due to its higher strength, faster setting properties, and suitability for structural applications.

Table 1: Properties of Cement

S.NO	PROPERTIES	CEMENT
1	Specific Gravity	**3.18**
2	Fineness	**2.2**
3	Consistency	**35%**
4	**Initial setting**	**30min**

b) Fine Aggregate (M-Sand)

Manufactured sand (M-sand) was used as fine aggregate in this project. It is produced by crushing hard granite stones into fine particles. M-sand provides better grading, improved strength, and reduced impurities compared to natural river sand. It fills the voids between coarse aggregates and contributes to the workability and strength of concrete.

c) Coarse Aggregate

Coarse aggregates of size 20 mm were used in the concrete mix. These aggregates are obtained by crushing hard stones and provide bulk and strength to the concrete. They occupy the maximum volume in concrete and help in reducing shrinkage. Properly graded coarse aggregates improve the load-carrying capacity and durability of concrete.

d) Pistachio Shell Powder (PSP)

Pistachio shell is an agricultural waste obtained as a by-product from the processing of pistachio nuts. Large quantities of these shells are discarded every year, leading to environmental disposal issues. Due to its lightweight, porous, and fibrous nature, pistachio shell has gained attention as a potential alternative material in construction.

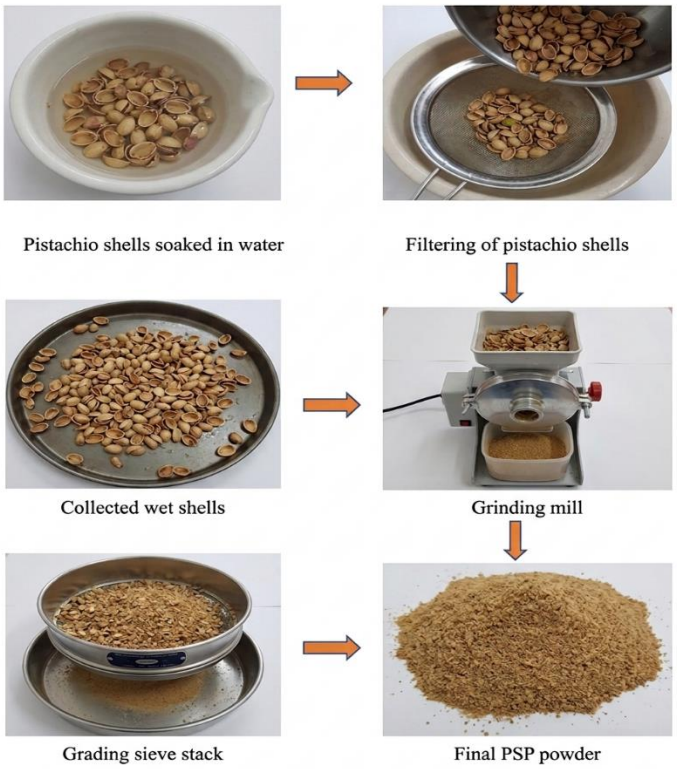
In this study, pistachio shells are processed into fine powder and used as a partial replacement for cement in concrete. The shells are collected, cleaned, dried, and ground to achieve a particle size similar to cement. The resulting pistachio shell powder (PSP) exhibits low density and high-water absorption characteristics, which influence the workability and strength of concrete.

Thus, pistachio shell powder can be considered as an eco-friendly and economical material for improving sustainability in concrete production.

e) Advantages of PSP

- Reduces cement consumption in concrete
- Helps in waste management and reduces environmental pollution
- Lowers carbon dioxide emissions from cement production
- Promotes sustainable and eco-friendly construction
- Economical compared to conventional materials
- Lightweight nature reduces overall concrete density

B. Methods



Pistachio shell concrete is prepared by partially replacing cement with pistachio shell powder (PSP) while maintaining the basic components of conventional concrete. The composition includes cement, fine aggregate, coarse aggregate, water, and PSP as a supplementary material. The composition of pistachio shell concrete is prepared by partially replacing cement with pistachio shell powder (PSP). The mix proportions were adopted for M25 and M40 grade concrete, maintaining constant aggregate content while varying the percentage of PSP.

Pistachio shell concrete consists of cement, pistachio shell powder (PSP), fine aggregate (M-sand), coarse aggregate, and water. In this study, PSP is used as a partial replacement for cement. The mix proportions adopted are 1:1:2 for M25 grade concrete and 1:0.75:1.5 for M40 grade concrete. The water-cement ratio used is 0.45 for M25 and 0.38 for M40.

Cement is replaced by pistachio shell powder at different percentages of 0%, 10%, 20%, 30%, and 40%, while keeping other materials constant.

C. MIX Proportions

Cement: Fine Aggregate: Coarse Aggregate = 1: 1: 2
Water-Cement Ratio (w/c) = 0.45

Table 1: Composition of M25 Concrete

Material	0% PSP	10% PSP	20% PSP	30% PSP	40% PSP
Cement (kg)	400	360	320	280	240
PSP (kg)	0	40	80	120	160
M-Sand (kg)	650	650	650	650	650
Coarse Aggregate (kg)	1200	1200	1200	1200	1200
Water (litres)	185	18	18	18	185

Cement: Fine Aggregate: Coarse Aggregate = 1: 0.75: 1.5
Water-Cement Ratio (w/c) = 0.38

Table 2: Composition of M40 Concrete

Material	0% PSP	10% PSP	20% PSP	30% PSP	40% PSP
Cement (kg)	450	405	360	315	270
PSP (kg)	0	45	90	135	180
M-Sand (kg)	600	600	600	600	600
Coarse Aggregate (kg)	1150	1150	1150	1150	1150
Water (litres)	165	165	165	165	165

V. CASTING OF CUBE

A. Casting of Concrete Cubes

Concrete cubes were cast to determine the compressive strength of concrete. Standard cube moulds of size 150 mm × 150 mm × 150 mm were used. Before casting, the moulds were cleaned and oiled to prevent adhesion of concrete. The prepared concrete mix was poured into the moulds in three equal layers. Each layer was compacted using a tamping rod to remove entrapped air and ensure proper compaction. After filling the moulds, the top surface was levelled and finished smoothly. The moulds were kept undisturbed for 24 hours at room temperature.After 24 hours, the specimens were demoulded and transferred for curing.

VI. Comparison of Costing and Cost Accounting

Material	M25 Concrete for 1m^3	10% PSP	
Cement (kg)	400	360	320
PSP (kg)	0	40	80

M-Sand (kg)	**Mix**	650	**Total Cost (₹)**	650	**Saving (₹)**	650	**Saving %**
Coarse Aggregate (kg)	Mix (kg)	1200	5340	1200	0	1200	0%
Water (kg)	10% PSP	185	5084	185	256	185	4.8%
w/c ratio	20% PSP	0.45	4828	0.45	512	0.45	9.6%
Material		Normal Concrete (0% PSP)		10% PSP		10% PSP	
PSP (kg)		0		40		40	

VII. RESULTS AND DISCUSSION

A. Workability Test Result

Mix	M25 Slump (mm)	M40 slump (mm)
0%	85	75
10%	78	72
20%	76	70
30%	60	55
40%	52	48

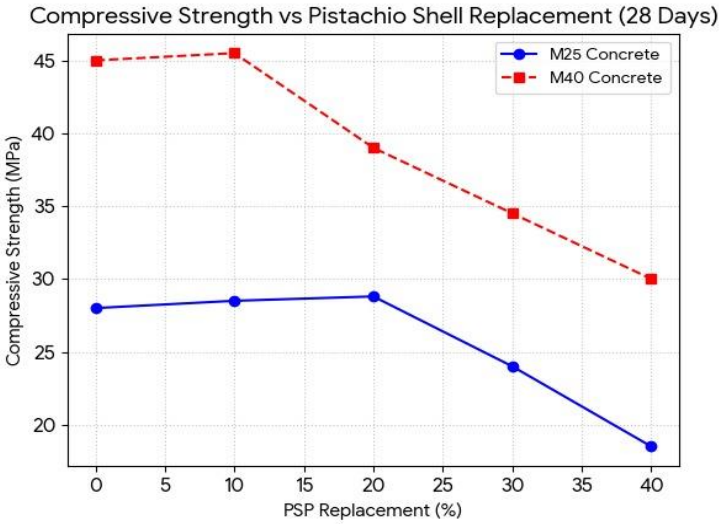
B. Compressive Strength Result

a) For M25 Concrete

Mix	7 days (MPa)	28 days (Mpa)
0%	18.5	26.0
10%	19.8	28.5
20%	20.2	29.1
30%	14.5	21.0
40%	12.0	18.5

b) For M40 Concrete

Mix	7 days (MPa)	28 days (Mpa)
0%	**28.0**	**45.0**
10%	**29.5**	**46.5**
20%	**24.0**	**39.0**
30%	**21.5**	**34.5**
40%	**18.0**	**30.0**



Observation: Higher PSP → higher porosity → more water absorption

D. Discussion

- Strength decreases gradually with PSP increase
- Up to 10–20% replacement is acceptable
- Beyond 30%, bonding reduces significantly
- M40 shows better performance than M25 due to higher cement content

VII. CONCLUSION

- PSP can be used as a partial cement replacement
- Optimum replacement level = 10–20%
- Workability decreases with PSP content
- Strength reduction is minimal at low replacement levels
- PSP promotes eco-friendly and sustainable construction
- Not suitable for full replacement of cement

Interest Conflicts

The author declares no conflict of interest.

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