

An Experimental Study on the Effect of Sodium Chloride (NaCl) on Tandur Slurry Powdered Mortar Cubes

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Abstract

The construction industry's pursuit of sustainable practices has intensified the search for supplementary cementitious materials. This study explores the viability of Tandur Slurry Powder (TSP), a waste byproduct from limestone polishing, as a partial replacement for Ordinary Portland Cement (OPC) in mortar, with a focus on resistance to sodium chloride (NaCl) attack. Mortar cubes were prepared with 0%, 20%, 40%, and 60% TSP replacement by weight. After 28 days of water curing, the cubes were subjected to NaCl solutions of varying concentrations (1%, 3%, 5%) for 7, 14, and 28 days. The mechanical and durability properties were evaluated through compressive strength tests, weight loss measurement, water absorption, and Ultrasonic Pulse Velocity (UPV). Results indicate that a 20% TSP replacement yielded the highest compressive strength (~32.8 MPa) before chemical exposure. However, under NaCl attack, strength loss increased proportionally with higher TSP content and longer exposure duration, with the most severe degradation (~16% loss) observed in 60% TSP samples exposed to 5% NaCl for 28 days. While TSP incorporation increased water absorption, the study concludes that TSP can be effectively utilized up to 20% replacement in applications with low risk of chloride attack, offering a promising avenue for waste valorization and reduction of cement consumption.

Keywords

Tandur Slurry Powder (TSP), Sodium Chloride, Mortar, Durability, Compressive Strength, Sustainability.

Introduction

Cement is widely used in construction but is energy-intensive and environmentally taxing. With increasing infrastructure demands, exploring alternative cementitious materials is crucial. Tandur Slurry Powder (TSP), a by-product of limestone polishing in Tandur, Telangana, India, is abundant and poses an environmental disposal challenge. This study

explores the feasibility of using TSP as a partial cement replacement in mortar, with emphasis on mechanical and durability characteristics under chloride exposure.

Materials and Methods

Ordinary Portland Cement (53 grade), Tandar Slurry Powder (TSP), fine aggregates, potable water, and sodium chloride (NaCl) solutions were used. Mortar cubes (70.6 mm) were cast with 0%, 20%, 40%, and 60% TSP replacement by weight. After 28 days of water curing, cubes were immersed in NaCl solutions (1%, 3%, 5%) for 7, 14, and 28 days. Tests conducted included compressive strength (per IS standards), water absorption, weight loss, and ultrasonic pulse velocity (UPV) tests. A total of 120 cubes were tested.

Results and Discussion

The experimental results revealed clear trends regarding the influence of TSP and NaCl on mortar properties. Water absorption capacity showed a direct correlation with TSP content, increasing from 2.5% at 0% TSP to 5.8% at 60% TSP, indicating a more porous microstructure as cementitious content is reduced. Conversely, workability, as measured by slump value, decreased from 65 mm to 40 mm with increasing TSP content due to the higher surface area and water demand of the finer TSP particles.

The compressive strength of mortar before NaCl exposure was significantly influenced by the TSP percentage (Figure 1). The maximum 28-day compressive strength of 32.8 MPa was achieved with a 20% TSP replacement. Beyond this optimal level, strength decreased due to the dilution of cementitious compounds, reaching 12.3 MPa at 60% TSP.

Exposure to NaCl solutions altered the strength development. A complex interaction was observed where lower TSP replacements (20%) showed resilience, even exhibiting a slight strength gain (up to 53.1 MPa in 1% NaCl for 28 days) potentially due to mild pore-filling and crystallization. However, this effect diminished with harsher conditions. Prolonged exposure (28 days) and higher NaCl concentrations (5%) led to significant strength degradation for mixes with high TSP content. The most severe loss was recorded for the 60% TSP mix in 5% NaCl for 28 days, with strength reduced to 19.4 MPa, a ~37% loss from its pre-exposure water-cured strength. This is attributed to the chemical attack on the weaker TSP-cement matrix, leading to leaching and micro-cracking.

Ultrasonic Pulse Velocity (UPV) values, an indicator of structural integrity, corroborated these findings. The UPV decreased from 4250 m/s for 0% TSP mortar to 3150 m/s for 60% TSP mortar in 5% NaCl, confirming increased internal voids and microstructural deterioration caused by both the reduced binding ability at high TSP levels and the deleterious effects of chloride intrusion.

Conclusions

1. Tandır Slurry Powder (TSP) can partially replace cement in mortar, with 20% replacement providing optimal mechanical properties.
2. Higher TSP contents (>20%) reduce compressive strength and increase water absorption.
3. NaCl exposure causes a complex response; while lower TSP mixes (20%) showed minor strength gains under mild conditions, higher TSP contents (>40%) and severe exposure (5% NaCl for 28 days) led to significant strength degradation, with a 37% loss observed for the 60% TSP mix.
4. This approach offers an environmentally friendly alternative for utilizing TSP waste, reducing cement consumption and promoting sustainable construction practices.

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