A's Binder: A Composite Road Binder for Sustainable Pavement Engineering

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Abstract

This paper presents an optimized formulation and theoretical analysis of "A's Binder," a sustainable composite road binder designed to improve pavement durability while reducing environmental impact. The composition integrates bitumen, plastic waste, fly ash, silica fume, and metallic fibers. Performance metrics including tensile strength, thermal resistance, water repellency, and fatigue life are evaluated against conventional bitumen. Economic viability and environmental benefits are discussed.

1 Introduction

The development of eco-efficient road binders is critical in addressing both infrastructure durability and plastic waste management. A's Binder integrates industrial byproducts and recycled materials to create a high-performance, cost-effective, and sustainable pavement solution.

2 Material Composition

- Bitumen: 50% — Base binding agent providing viscosity and adhesion.
- Waste Plastic: 12% — Enhances elasticity and crack resistance.
- Silica Fume: 8% — Filler with pozzolanic properties to improve chemical resistance.
- Fly Ash: 20% — Improves density, reduces permeability.
- Metallic Fibers: 10% — Adds tensile strength and minimizes micro-cracking.

3 Theoretical Performance Analysis

3.1 Physical Properties

Composite binder is denser and more stable under heat and load. It resists deformation better than pure bitumen.

3.2 Chemical Properties

Synergistic behavior among components ensures chemical durability. Silica and fly ash provide pozzolanic reactions enhancing binder matrix.

3.3 Durability and Strength

- Tensile Strength: Higher due to metallic fibers.
- Crack Healing: Bitumen-plastic mix allows thermal softening and recovery.
- Fatigue Resistance: Increased due to fiber and polymer synergy.

3.4 Thermal Resistance

- Traditional softening point: 60°C
- A's Binder softening point: ¿90°C

3.5 Water Resistance

- Plastic content increases hydrophobicity.
- Silica fume and fly ash reduce pore connectivity.

3.6 Flexibility and Fatigue Life

Plastic increases elasticity, and metallic fibers redistribute stress — extending fatigue life 2–3x.

4 Cost Analysis

- Estimated cost: **INR 40,000–45,000/ton**
- Estimated profit: **INR 12,000–17,000/ton**
- Incentives: Eligible for green construction subsidies.

5 Environmental Benefits

- Plastic: Diverts waste from landfills.
- Fly Ash, Silica Fume: Recycles industrial byproducts.
- Overall lower carbon footprint.

6 Conclusion

A's Binder is a novel, sustainable alternative to traditional binders. It leverages the strength of metallic fibers, the flexibility of plastic, and the chemical robustness of pozzolanic materials to deliver improved road performance with a positive environmental impact.

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