Effect of Waste Oil on Warm Mix Asphalt Block Pavement

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Abstract

This study examines the impact of three oils—waste engine oil (WEO), waste cooking oil (WCO), and soya bean oil (SBO)—as rejuvenators in warm mix asphalt (WMA) block pavement. Through lowering production temperatures, enhancing binder characteristics, and utilizing waste materials, these oils provide advantages in terms of sustainability and cost-effectiveness. This report compiles experimental results on structural integrity and long-term durability, highlights comparative advantages and disadvantages, and points out areas needing further investigation.

1. Introduction

Warm mix asphalt reduces manufacturing temperatures (100–140 °C) compared to hot mix asphalt (HMA), offering reduced fuel use and emissions [11]. As reclaimed asphalt pavement (RAP) usage grows, restorative additives such as WEO, WCO, and SBO are crucial for recovering binder elasticity and functional properties.

2. Materials & Methodology in Reviewed Studies

2.1 Waste Engine Oil (WEO)

WEO (5-10 %) in WMA with RAP and copper slag, showing softening of aged binder, reduced stiffness and rutting performance, but increased fracture energy [2]. 3–5 % WEO in WMA, improving penetration and softening point, though stiffness declined [5]. WEO raised Marshall stability and moisture stripping resistance in HMA containing up to 50 % RAP [7].

2.2 Waste Cooking Oil (WCO)

WCO in WMA block pavement—highlighting improved fatigue cracking resistance and mechanical performance [4], [10]. Chemically modified WCO of 25 % substitution with modified WCO significantly improved dispersivity and binder Heithaus parameters [8]. WCO rejuvenation, affirming improved low-temperature cracking resistance but cautioning moisture susceptibility [3].

2.3 Soya Bean Oil (SBO)

Vegetable oils such as SBO improve low-temperature behavior and fatigue resistance in aged binders, depending on binder grade [1].

3. Comparative Summary

Oil Type	Dosage (%)	Penetration (mm)	Softening Point	Marshall Stability

			(°C)	(kN)
WEO	5–10	65–80	42–48	8.5–10.2
WCO	2–7	70–90	38–46	9.1–11.0
SBO	1–5	68–85	40–45	8.7–10.0

All oils improved penetration values and reduced the softening point, indicating increased binder flexibility. WCO demonstrated the highest Marshall stability range among the oils studied, showing its potential in enhancing block pavement durability.

4. Effects on WMA Block Pavement

- **Rheology:** All oils reduce stiffness and boost penetration; WCO often out performs WEO in softening aged binder [2], [11].
- **Mechanical Performance:** WEO increases fracture energy [2]; WCO shows significant fatigue and block pavement benefits [1], [22].
- **Environmental/Economic:** Use of waste oils diverts significant waste volumes (e.g., >50 M t of WCO globally in 2020) [7], [20]. Lower mixing temperatures translate into fuel/emission savings.

5. Gaps & Future Directions

- Long-term field studies remain limited.
- Optimization of oil dosage to balance rutting and cracking is needed.
- Combining oils with polymers, antistrip agents, or nano-additives (e.g., ZycoTherm) may improve performance [18].
- Fuller life-cycle emission and cost-benefit analyses are scarce.

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