Improving the properties of asphalt binder 60/70 by incorporating naphthalene-containing mineral oil derived from petroleum by-products

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Bitumen, a black and opaque hydrocarbon mixture, serves as a critical binder in asphalt due to its adhesive and binding properties. However, asphalt pavements, particularly those utilizing 60/70 penetration grade bitumen, commonly experience challenges such as rutting, cracking, and deformation under moderate to elevated temperatures. These distresses prevalent on local road surfaces underscore the need for enhanced bitumen performance to extend pavement durability. This study aims to enhance the properties of 60/70 penetration grade bitumen by incorporating naphthalene containing mineral oil, which is a by-product in the petroleum industry. The primary objectives of the study include achieving a finely structured bitumen matrix, maximizing aggregate coating efficiency, developing asphalt mixtures with superior performance at reduced bitumen content, mitigating common asphalt-related defects, and realizing environmental and economic benefits through sustainable modifications. The modification process involved blending naphthalene-containing industrial oil with 60/70 bitumen at varying concentrations (1–9%, w/w) under ambient conditions. Gas chromatography-mass spectrometry analysis was employed to precisely identify and quantify naphthalene content (22.7%) in the industrial oil. The π-π stacking mechanism between naphthalene and bitumen aromatic fraction is expected to improve the mechanical performance without compromising the fundamental integrity of the material. The naphthalene-modified bitumen, containing 5% oil exhibited improved aggregate coating ability (99%), yielding more uniform asphalt mixture with enhanced durability and fewer weak zones. The dynamic shear rheometer value (performance grade 58) for the modified bitumen, clearly demonstrated its suitability for road construction in Sri Lanka, ensuring optimal performance under the region's challenging high-temperature and traffic conditions. The stiffening effect evidenced by reduced flow values imparts greater rigidity and reduced plasticity, which effectively minimizes the permanent deformations. Furthermore, the modified binder facilitated the use of lower bitumen content in the standard mixture, offering a cost-effective alternative. This research successfully demonstrates that naphthalene-containing mineral oil serves as an effective and economical additive for enhancing the performance of bitumen. The findings contribute valuable insights to the field of bitumen modification, providing a practical and sustainable approach to address common asphalt pavement distresses with a potential to apply in road constructions.

Keywords: *Naphthalene, Bitumen, Extra black asphalt, Mineral oil, Aggregate coating ability*