

Sustainable Innovation of Colored Bitumen via Naphthalene Modified Base and Aesthetic Enhancement in Pavement without Asphaltene Disruption

Ushani Wijenayake, Anuruddha Kumara

Abstract

Due to the high asphaltene content, traditional bitumen is opaque and exhibits a deep black hue, attributable to the dense molecular matrix comprising asphaltenes, resins, and complex aromatic hydrocarbons. This structural composition facilitates extensive light absorption across the visible spectrum (400–700 nm), which reduces the visible pigmentation. Typically, all the bitumen grades widely used in Sri Lanka present several limitations for colored applications, which manifest inherent limitations for aesthetic functionalization, driven by the light-scattering and absorptive properties of their polycyclic aromatic frameworks. Nonetheless, the escalating demand for visually distinctive and functionally zoned pavements, such as high-visibility urban corridors, vehicle parks, walking paths, model roads, and colored lanes for non-motorized traffic, has significantly grown, and that will improve and step up the road construction field and even city developments. Furthermore, the poor pigment compatibility of unmodified bitumen leads to dull coloration, unstable dispersion, and rapid weathering. Attempts to incorporate pigments directly into unmodified bitumen often result in phase separation or compromised mechanical performance. This study addresses the central research question: How can naphthalene modified bitumen (NB) be engineered to produce pigmented bitumen and ensure long-term aesthetic durability in colored asphalt without perturbing the bitumen's intrinsic chemical composition and giving an equal dispersion of pigment throughout the base bitumen? The primary objective is to evaluate the efficacy of naphthalene, a polycyclic aromatic hydrocarbon with a conjugated electron system, as a chemical modifier to partially disrupt the colloidal stability of bitumen while preserving critical asphaltene fractions. One of the most compelling aspects of this study is that humans tend to recognize colors and shapes more intuitively than written signs. As a result, colored bitumen (which can produce colored asphalt mixes with heat-resistant pigments) can serve as a visual communication tool. This allows even individuals who cannot read road signs to understand the meaning or function of specific colored pavement areas. Naphthalene is introduced as a chemical modifier to partially soften the colloidal structure of the bitumen while maintaining the critical asphaltene content. This modification enhances fluidity and pigment dispersion without sacrificing strength, elasticity, or thermal resistance. Unlike clear synthetic binders or low-viscosity emulsions, NB provides a cost-effective and locally adaptable alternative for durable colored pavement materials using a modified moderate shear thermal mill. NB was blended with appropriate pigments such as Iron oxide (red), chromium oxide (green), a suitable plasticizer, and matched white oil in the modified mill under a specific speed and heat to incorporate all particles into the NB matrix. The resulting samples underwent physical and chemical testing as UV aging, temperature susceptibility, and pigment stability were also examined to simulate real world Sri Lankan conditions. Road infrastructure in Sri Lanka largely depends on conventional asphalt concrete, with minimal focus on visual demarcation, dedicated lanes for cyclists and pedestrians, or temperature-moderating pavement

solutions. The introduction of colored NB for colored asphalt surfaces presents numerous benefits in this setting. It allows for clear differentiation of low-traffic zones, such as designated areas for pedestrians, bicycles, and schools, particularly in rural and peri-urban regions. Colored asphalt contributes to greater road safety, especially in areas prone to heavy rainfall or poor lighting, by making key zones more visible. The technology is also compatible with the existing hot mix asphalt methods, requiring no major shifts in current practices. Additionally, the use of light-colored, reflective surfaces could help in addressing urban heat concerns. Most importantly, this innovation supports modernization and visual enhancement of roadways, aligning with broader goals in smart city planning and tourism-focused infrastructure development. By incorporating color into current pavement systems without the need for complex redesign or costly imported materials, NB-based solutions offer both functional and aesthetic upgrades to Sri Lanka's transportation landscape. Future work engaging with NB based productions will explore large-scale field trials, environmental assessments of modifier usage, and the development of bio-based or green modifiers as sustainable alternatives.

Keywords: *naphthalene modified colored bitumen, aesthetic pavement designs, pigment dispersion, advanced road construction*

Author details;

1. Post Graduate Student, Department of Chemistry, Faculty of Science, University of Colombo.
ushaniwijenayake@gmail.com
2. Research Assistant, Research & Development Division, Road Development.
anuruddharda@gmail.com