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RESEARCH BRIEF
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Project Title
Evaluating the Structural Properties and Cost-Effectiveness of Graphene-modified Asphalt

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Further Resources
Final Report link
Other links
(QR codes work well)

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Introduction

With the increased demand and cost of asphalt binder, limited highway maintenance budgets, and the need to reduce greenhouse gas emissions from asphalt production, it is important for engineers and highway agencies to capitalize on new asphalt technologies that might increase pavement service life. The use of nanomaterials (nanoclays, nanosilica, nano-silicone dioxide, nano zinc oxide, nano titanium oxide, and carbon nanomaterials) in asphalt binder has received significant attention due to these materials' potential to improve performance and durability of asphalt pavement. The types of carbon nanomaterials incorporated in asphalt binders primarily includes carbon nanotubes, graphene oxide (GO), and graphene nanoplatelets. Amongst these carbon nanomaterials, GO has exhibited the most promise in the improvement of asphalt binder properties; however, the high cost of GO incorporated at the necessary scale for roadway asphalt pavement projects could potentially outweigh the benefits. Through a life cycle cost analysis (LCCA), this study aims to evaluate the cost effectiveness of the use of GO in asphalt binder to increase pavement longevity.

Methods

The execution of this study involved laboratory testing, AASHTOWare Pavement ME design simulations, and LCCA of pavement designs with different asphalt pavement mixture scenarios. The asphalt binders with different GO dosages were subjected to a series of laboratory tests in the CDOT asphalt laboratory including the Dynamic Shear Rheometer (DSR), the Rolling Thin Film Oven Test (RTFO), the Pressure Aging Vessel (PAV), and the Bending Beam Rheometer (BBR). The results of the lab tests were input into the AASHTOWare Pavement ME software with representative pavement sections to determine pavement design life. The design life, rehabilitation schedule, and cost for the control and GO binders were evaluated through a LCCA.

Conclusions

Laboratory testing indicated that a 0.05% by mass of binder was the optimum dosage for a neat (non-modified) PG 64-22 binder and 0.2% by mass of binder was the optimum dosage for an SBS modified PG 64-28 binder. The lab results for these binder dosages were input into the AASHTOWare Pavement ME software for a 20-year design life of a simulated highway pavement on I-70 on the eastern plains of Colorado. The software indicated that GO addition had the greatest impact on rutting performance, so rutting was selected as the primary factor to dictate pavement mill and overlay rehabilitation in the LCCA model. The LCCA results showed the cost of using 0.05% GO in a PG 64-22 was approximately equal to the cost of using a conventional PG 64-22 binder. The LCCA also showed the cost of using 0.2% GO in a PG 64-28 binder was approximately $18.6M more than a conventional PG 64-28 binder over

	the life of the pavement. Future research should consider the low temperature cracking performance of binders with GO addition since that was not evaluated in this study. **Potential Impacts and Benefits** This study developed an initial framework to perform a benefit-cost analysis on the use of GO, or other asphalt binder additives, to improve asphalt pavement performance. Future research on LCCA of GO should consider additional performance metrics to the benefit-cost framework, such as fatigue cracking, International Roughness Index (IRI), and complete asphalt mixture laboratory testing. More research on GO and carbon nanomaterials is necessary before the materials could be adopted for application in road construction projects at the state highway agency level.