EVALUATION RHEOLOGICAL PROPERTIES OF NANO CLAY MODIFIED BITUMEN

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DECLARATION OF THE CANDIDATE AND THE SUPERVISOR

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ABSTRACT

Bitumen is a complex hydrocarbon, and its rheological behavior is also very complex. The rheological behavior of bitumen changes from purely viscous to elastic as per the duration of load applied and its temperature. When considering the road pavement, bitumen is the main material, and it plays a major role in many aspects of road performance. Many investigations have been done related to the modified bitumen to enhance the fulfillment of the bituminous mixture. Most of the Roads are not performed well during their whole design period and experienced rutting and cracking in the bituminous layer due to t poor performance of bituminous binders. So, bitumen modification has been the significant approach today, and modified bitumen is effectively used in many countries during the last three decades to construct pavements. This research considers a laboratory-scale assessment of the conventional and the essential rheological characteristics of modified binders using Nano clay.

Montmorillonite (MMT) nano clay is widely using in many engineering applications. In Sri Lanka, few types of research were done about the usability and characterization of MMT clay, which is available at the Mannar area near the Giant tank. The clay powder prepared from the original bulk clay sample was taken from the above area. It was added to the original bitumen of 60/70 penetration grade binder to prepare the modified binder.

Modified bitumen samples were prepared by adding nano clay and mixed at 160^0C with a mixing time of 25minutes. The prepared modified binder with nano clay was then checked with the penetration, softening temperature, ductility, and dynamic viscosity tests to compare the properties with the original binder. Finally, modified bitumen of each sample was evaluated for the rutting and fatigue resistance for fresh and aged samples with the Dynamic Shear Rheometer (DSR) test, Rolling Thin Film Oven (RTFO) test, and Pressure Aging Vessel (PAV) test.

As per the results obtained from the tests, the viscosity and softening point increase with clay percentage. Penetration and ductility have decreased with increasing clay percentage. Rutting resistance has improved compared to conventional bitumen, and it was shown that modified bitumen with 8% clay improved to PG 76 grade from PG 70 grade of the original sample. All other samples except for 8% clay showed PG 70 grade with 2%, 4%, 6%, and original bitumen sample. There was no much effect on the fatigue resistance when the samples were subjected to the DSR test after the PAV test. At the end, Fourier Transform Infrared (FTIR), Differential Scanning Calorimetry and Thermo Gravimetric Analyzer (DSC and TGA) tests have been done

for original bitumen samples as well as modified bitumen samples with 4% MMT based nano clay to verify any chemical bonds between the bitumen and nano clay. The result of FTIR and DSC/TGA has shown, no chemical interaction between the bitumen and nano clay.

The conclusion from these results is that the montmorillonite clay modification supported improving the softening point from 51^0C of original bitumen to 53^0C with 4% MMT modified clay. The penetration has been reduced to 45 (0.1mm) from 60 which was in original bitumen sample with 4% MMT modified clay. The ductility value has been reduced from 151cm of original bitumen sample to 90cm with 8% of MMT modified clay. The viscosity increased from 0.38PaS of original bitumen to 0.41PaS with 2% MMT modified clay. Again, it has reduced to 0.40PaS with 4% of clay sample, and then viscosity value remains unchanged up to 8% of MMT modified clay sample. Furthermore, the rutting resistance has been increased compared to the original bitumen sample. The rutting parameter ($G^*/\sin\delta$) has increased up to 2.18 with6% of MMT modified clay sample and it was 1.42 in the original bitumen sample.

Key Words: Nano clay, Montmorillonite, Viscosity, Penetration, Softening point,

Dynamic Shear Rheometer

DEDICATION

To all who guide me to success.

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LIST OF ABBREVIATIONS

Abbreviation	Description
AASTHO	American Association of State Highway Officials
ASTM	American Society of Testing and Materials
BBR	Bending Beam Rheometer
DSC	Differential Scanning Calorimetry
DSR	Dynamic Shear Rheometer
DTT	Direct Tensile Tester
FTIR	Fourier Transform Infrared Spectroscopy
MMT	Montmorillonite
PAV	Pressure Aging Vessel
PG	Performance Grade
RTFO	Rolling Thin Film Oven
RV	Rotational Viscometer
SHRP	Strategic Highway Research Programme
TGA	Thermo Gravimetric Analysis
XRD	X-ray Diffraction