INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title: Evaluation of the Properties of Pyrolytic Char Modified Asphalt Binders and Mixtures

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SHORT ABSTRACT

The total road network length of 6.2 million kilometres in India is the second largest in the world. The major share of roads in India is built as flexible pavements. The most common types of distresses in flexible pavements have been recognised as rutting, moisture damage, and fatigue. To alleviate pavement distresses and address the challenges associated with higher: temperatures, tyre pressures, and axle load levels experienced by pavements, asphalt binder is frequently modified for enhanced performance and extended pavement service life. In recent years, there has been a strong push toward developing sustainable solutions for managing post-consumer tyre and plastic waste streams. In this regard, pyrolysis technology has garnered scientific attention for its ability to minimise waste volume while also allowing for energy valorisation. The two primary pyrolysis products are liquid oils and gases, which have high potential as fuels and precursors to important petrochemicals. The third product, solid carbonaceous pyrolytic char, is considered a by-product with relatively few applications/uses. This study evaluated the utilisation of tyre pyrolytic char (TPC) and plastic pyrolytic char (PPC) as asphalt modifier and evaluated the effect of their incorporation on the properties of asphalt binders as well as on the design and performance attributes of bituminous concrete mixes. The study focused on a multi-faceted investigation that included: (a) characterisation of the two pyrolytic chars (TPC and PPC), (2) characterisation of the TPC and PPC modified asphalt binders focusing on conventional, storage stability, rheological, ageing, microscopic, and thermo-chemical evaluations, and (3) characterisation of asphalt mixtures fabricated with TPC and PPC modified asphalt binders with a focus on their design, rutting performance, moisture damage performance as well as on cracking and fatigue life attributes. A total of nine modified binders/mixtures were studied with a control binder and four binders, each with TPC and PPC modification levels of 5, 10, 15, and 20% by weight of binder.

Characterisation of the two pyrolytic chars showed that TPC had a finer particle size distribution with a lower volatile matter content and more stable thermal characteristics than PPC. The incorporation of polyphosphoric acid (PPA) content of 1.0% and sulfur content of 0.3% produced the lowest storage separation for TPC modified binders. Storage stability analysis of PPC modified binders also showed that the 0.3% sulfur dosage resulted in the best

performance. The rutting performance of char-modified binders improved with an increase in char dosages up to 20%. Based on the fatigue test on binders, it was found that the optimum performance was achieved at a 10% dosage of both TPC and PPC. Rheological as well as Fourier transform infrared spectroscopy (FTIR) based ageing indices showed that TPC modified asphalt binder suffered lower ageing compared to the control and PPC modified binder. An increase in the production temperatures was observed with an increase in pyrolytic char content. The findings from leaching tests showed that TPC and PPC could be safely used in asphalt mixtures for pavement construction. Stiffness and rutting performance of the bituminous concrete mixtures showed a consistent improvement with an increase in TPC and PPC dosage up to 20%, as also observed in binder testing. Comparing the fatigue, cracking, and moisture damage performance evaluation results, it was found that the optimum performance was achieved at 10% dosage of both TPC and PPC. The overall findings of this study show that 10% dosage of these chars is the most favourable dosage considering the enhancement in the rheological characteristics and the improvements in rutting, moisture damage, cracking, and fatigue performance of asphalt mixtures. Utilization of TPC and PPC in asphalt binder modification will support the management of plastic and tyre wastes through pyrolysis technology and will further enhance sustainability in pavement construction practices.