Prediction of Marshall Parameters of Modified Bituminous Mixtures Using Artificial Intelligence Techniques

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ABSTRACT

This study presents the application of artificial neural networks (ANN) and least square support vector machine (LS-SVM) for prediction of Marshall parameters obtained from Marshall tests for waste polyethylene (PE) modified bituminous mixtures. Waste polyethylene in the form of fibres processed from utilized milk packets has been used to modify the bituminous mixes in order to improve their engineering properties. Marshall tests were carried out on mix specimens with variations in polyethylene and bitumen contents. It has been observed that the addition of waste polyethylene results in the improvement of Marshall characteristics such as stability, flow value and air voids, used to evaluate a bituminous mix. The proposed neural network (NN) model uses the quantities of ingredients used for preparation of Marshall specimens such as polyethylene, bitumen and aggregate in order to predict the Marshall stability, flow value and air voids obtained from the tests. Out of two techniques used, the NN based model is found to be compact, reliable and predictable when compared with LS-SVM model. A sensitivity analysis has been performed to identify the importance of the parameters considered.

Key Words: Marshall stability, flow value, air voids, waste polyethylene, ANN, LS-SVM

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1. INTRODUCTION

Bituminous mixtures mainly comprise of aggregates, both coarse and fine, mineral filler, and bitumen, heated separately, mixed together appropriately and compacted as per the prescribed procedure to result in strong and durable paving mix that can resist the heavy wheel loads from the traffic. The Marshall tests are simple and low cost tests used characterization of bituminous mixes. The parameters used such as Marshall stability and flow value resulting from Marshall tests on bituminous mixtures relate to some extent on the performance of highway bituminous pavement. As per Brown et al. (2001), the Marshall test was being widely used with the basic purpose of measuring the strength of an asphalt mixture that had been compacted to a standard laboratory compactive effort. This test is also used as part of the Marshall mix design procedure for optimizing the design asphalt content, and in the quality control of asphalt mixtures. Two properties are basically determined: the maximum load the specimen will carry before failure (known as the Marshall stability) and the amount of deformation of the specimen before failure occurs (known as Marshall flow) [4]. Cooper and Pell (1974) observed that the stability of asphalt concrete pavements depends on the stiffness of the mix, bitumen content, softening point of bitumen, viscosity of bitumen, grading of aggregate, construction practice, traffic, and climate conditions [5]. The air voids also contribute to some extent on these two properties in respect of mixes with same composition and characteristics. The parameters such as Marshall stability value, flow value and air voids of the bituminous mixtures quantify to certain extent the distresses of the bituminous mixes in the field. These parameters in respect of the bituminous mixtures are found to be enhanced by various ways and one such way is use of polymers. Kalantar et al. (2012) made a review of use of virgin and waste polymers in improving the engineering properties of bituminous mixes. Low density polyethylene when modified with bitumen has been found to enhance the Marshall properties of bituminous mixes [9]. As reported by Panda and Mazumdar (2002), Low-density polyethylene (LDPE) has been used by many to modify asphalt cement and to improve the properties of bituminous mixes (hot-mix asphalt). In their investigation, reclaimed polyethylene (PE) obtained from LDPE carry bags, was used to modify asphalt cement. The basic properties of modified binder and mixes containing such binders were studied and compared with those of asphalt cement [17]. However, in this present study the bituminous mixture has been modified with the addition of waste polyethylene in the form commercially available milk packets processed in the form of fibres, to result in improvement of the engineering properties of bituminous mixtures in addition to partly solving the management problem of solid waste of the surrounding environment. The variations in the Marshall parameters considered in this study such as Marshall stability value, flow value and air voids of modified and un-modified bituminous mixture for different aggregate gradings, bitumen contents and waste polyethylene concentrations in mixes were studied. The Marshall tests for bituminous mixture are quite time consuming process, which requires human effort. Hence the present study intends towards the modeling of the stability value, flow value and air voids of modified bituminous mixture to identify their relationships with bituminous mixture ingredients