Effect of Ferrochrome (FeCr) Slag Aggregate on the Rutting Performance of Hot Mix Asphalt Concrete

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Abstract

Ferrochrome slag (FeCr) is a by-product material of high-carbon Ferrochromium metal which is a primary component of stainless steel. The physical and mechanical properties of FeCr slag are relatively similar to the properties of natural aggregate. FeCr slag can be used as coarse or/and fine aggregate in hot mix asphalt (HMA) pavement.

In this research, FeCr slag was used as partial and full replacement of the natural aggregate in hot mix asphalt (HMA). The main objectives of this research were to investigate the potential use of Omani produced FeCr slag, as an aggregate in bituminous base and wearing course pavement layers and to evaluate its performance in terms of expected rutting. The FeCr slag was supplied by Al Tamman Indsil Ferrochrome LLC at Sohar Free Zone, Oman. Natural aggregate was supplied by Parsons international Company LLC. Virgin Richmond asphalt of grade 60/70 was used as a binder. The FeCr slag aggregates were used as partial replacement to selected sizes of coarse and fine aggregates. Full replacement of natural aggregates by the FeCr slag was also studied. The resistance of HMA to moisture-induced damage was evaluated. Dynamic modulus laboratory test was used for the performance evaluation. The dynamic modulus results were fitted into master curves. Accumulated rut depth analysis was conducted by Mechanistic-Empirical Pavement Design Guide (MEPDG) performance model.

In general, the moisture resistance of FeCr mixes were similar to the control mix containing natural aggregates only. Utilization of FeCr slag as coarse aggregate for base course and wearing course asphalt mixes increased the dynamic modulus $|E^*|$ compared to the control mix. However, using FeCr slag as aggregate in both base layer and surface layer increased the accumulated rut depth compared to the control mix. Utilizing FeCr slag as coarse aggregate replacement only (as opposed to fine aggregates or full replacement) in base course and surface course mixes is promising, the results were closer to those of the control mix. Further investigation is recommended by utilizing smaller fractions of FeCr slag as coarse aggregate in HMA. Investigation of changing the gradation is also recommended, as an increase in the finer fraction in the case of coarse FeCe slag replacement might reduce the binder content and therefore reduce rutting. FeCr slag is not recommended to be used as full replacement of the natural aggregate. Economic analysis should be conducted to determine the benefit of using FeCr slag.