

Heavy Metal Content and Leaching Potential of Recycled Glass Beads Used in Pavement Markings

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Executive Summary:

Recycled glass beads are incorporated into pavement marking systems to improve nighttime roadway delineation, marking visibility, and safety by retro-reflecting vehicle headlights. While the benefits of using recycled glass beads in pavement markings is well established, concerns over the presence of heavy metals in recycled glass bead products prompted AGBMA to sponsor research to: 1) determine the composition of heavy metals in samples of recycled glass beads provided by the sponsor, and 2) investigate the leaching potential of arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), nickel (Ni), and lead (Pb) from the provided recycled glass bead samples under laboratory conditions.

AGBMA provided TTI researchers 3 independent 50 lb batches of Type I AASHTO M247 beads for testing. Subsamples from each of the provided batches were characterized for their total metals content and their potential to leach metals. The total metals content was determined by dissolving the beads in highly alkaline solution and analyzing the solution for metals according to EPA Method 6020A. Mean \pm standard deviation metals contents for the provided samples (in units of $\mu\text{g}_{\text{metal}}/\text{g}_{\text{bead}}$) were determined to be:

Bead	As	Cd	Cr	Cu	Pb	Ni	Σ Metals
Batch 1	83.3 \pm 1.42	5.92 [†]	35.8 \pm 1.32	8.88 [†]	21.7 [†]	31.1 \pm 5.85	186 \pm 3.56
Batch 2	308 \pm 23.6	ND	ND	ND	77.4 \pm 27.7	76.4 \pm 4.17	462 \pm 18.3
Batch 3	393 \pm 6.53	ND	23.7 [†]	ND	81.0 \pm 7.98	ND	497 \pm 7.29

ND – not detected; [†] only one of the three replicates had measurable concentrations

Following the composition study, a column leaching system was used to investigate the effect of column eluent solution pH, ultraviolet light exposure, temperature exposure, and abrasion on metal release from the beads. Results of one way analysis of variance and Tukey's multiple comparison testing indicate that solution pH and abrasion affect the mean As and Σ metals content leached into solution. However, no effect on the mean amount of As or Σ metal leached was observed due to temperature or UV exposures.

The overall amount of Σ metal released during the 48 hour column studies was $< 0.2\%$ of the Σ metal content of the beads. However, As concentrations in the column effluent samples were $\geq 100 \mu\text{g}/\text{L}$ for Batch 1 and $\geq 3500 \mu\text{g}/\text{L}$ for Batch 2 and 3 during the first hour of collection. After one hour, observed metal concentrations in the column effluent decreased rapidly. The amount of leaching observed was also greater for smaller particle size fraction samples. Therefore, the fast initial metals release coupled to the finding that smaller particle size fraction releases more metal into solution indicates that leaching is occurring.