Economic Considerations for Asphalt Pavement Recycling Techniques

Dennis Morian, PE; Luis Ramirez, M.Sc.

Introduction

As the technologies of recycling hot mix asphalt (HMA) pavement materials have evolved, debate has arisen in some areas of the industry over which recycling method affords the best value to the owner. The selection of a rehabilitation method requires consideration of several factors such as condition of the existing pavement, availability of materials, time constraints, and economics.

This study focuses on the economic factors and provides a methodology for assessing the most beneficial use of recycled asphalt pavement materials in terms of cost. To do so, it is important to compile information about both costs and performance of the various recycled asphalt pavement materials produced. A cost benefit analysis must be based on the cost of production of paving material associated with each process, and the anticipated performance of that form of recycled asphalt pavement.

Objectives

- To provide a methodology for assessing the most beneficial use of recycled asphalt pavement for a particular project.
- To develop a Benefit Cost Analysis Model considering cost and performance for HMA production incorporating (Recycled Asphalt Pavement) RAP, Cold in-place Recycling, Cold Plant Recycling, and Hot in-place Recycling.

Pavement Recycling Methods

- HMA incorporating RAP
- Cold in-place Recycling
- Cold Plant Recycling
- Hot in-place Recycling

Cost Model

- Rehabilitation Alternatives Cost Factors

<table>
<thead>
<tr>
<th></th>
<th>Virgin HMA</th>
<th>Hot Plant Recycling</th>
<th>Cold in Place Recycling</th>
<th>Cold in Place Recycling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobilization</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>StockPiling</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Crushing</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Recycling Agent</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Virgin Aggregate</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Asphalt Cement</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

- Total Initial Cost Model

\[
TIC = RAP + MC + PC + MobC + HC + PavC
\]

Where:
- \( TIC \) = Total Initial Cost (S/Time)
- \( RAP \) = RAP Removal Cost (S/Time)
- \( MC \) = Recycled Mix Cost (S/Time)
- \( PC \) = Plant Costs (S/Time)
- \( MobC \) = Mobilization Cost (S/Time)
- \( HC \) = Hauling Cost (S/Time)
- \( PavC \) = Paving Cost (S/Time)

Variables Considered in Calculation of Cost Factors of Equation 1

- \( RAP \) = RAP Removal Cost (S/Time)
- \( MC \) = Recycled Mix Cost (S/Time)
- \( PC \) = Plant Costs (S/Time)
- \( MobC \) = Mobilization Cost (S/Time)
- \( HC \) = Hauling Cost (S/Time)
- \( PavC \) = Paving Cost (S/Time)

- Equivalent Annual Cost

\[
EAC = \frac{TIC \times (1 + \delta)^n}{(1 + \delta)^n - 1}
\]

- Cost Benefit Ratio

\[
\frac{B}{C} = \frac{EAC_{Recycling\ Method}}{EAC_{Virgin\ HMA}}
\]

- Structural Layer Contribution to the Cost Benefit Ratio

\[
\frac{B}{C} = \frac{EAC_{Recycling\ Method} \times \text{Structural Layer Coefficient (Virgin HMA)}}{EAC_{Virgin\ HMA} \times \text{Structural Layer Coefficient (Recycling Method)}}
\]

Conclusions

- Recycling options are typically more economical than the use of all virgin material in developing an asphalt paving mix. In this analysis only the case where RAP is secured from the same project has been considered. The case of off-site RAP could be added to the analysis if applicable.
- Increasing the percentage of RAP material used in a recycled mix generally reduces the relative cost of the mix. There may be environmental and production related factors which limit the RAP percentage of hot plant produced material, from a practical perspective.
- The total volume of material affected by the use of recycling must meet some minimum to support reasonable production costs. Above this threshold little impact is observed on the B/C for the various recycling processes.
- It is generally observed that the in-place recycling processes have reduced material handling and production costs, which makes them economically advantageous in many situations.
- When the relative structural value of a recycled pavement layer is considered, the difference in the benefit cost ratio is reduced from the case when only the volume of material produced is taken into account. These results are based on the relative structural values assigned to the various recycled materials by the individual agency.
- The methodology presented herein will provide useful guidance to agencies in considering the economics of the asphalt pavement recycling techniques currently in common use. It must be noted that average industry input values have been used for these sample analysis, and that locally applicable input values should be used by individual agencies for specific cases.