2.0 Structural Design

New Pavements and Overlays

Outline

- Terminology
- Caltrans Practices
- 2005 Study
- Revised Caltrans Practices
- RAC Project Selection
- Cost Analysis

Terminology

- Hot-mix asphalt (HMA) replaces the term dense-graded asphalt concrete (DGAC)
- Caltrans Highway Design Manual (HDM)
- Caltrans Flexible Pavement Rehabilitation Manual (FPRM)
- Asphalt Rubber Usage Guide (AR Guide)
- Mechanistic-empirical (M-E) based analysis and design
Caltrans Practice – New Pavements
- New pavements – Caltrans does NOT have a standard practice for the use of RAC in new pavement construction

Caltrans Practice – Overlays
- Based on FPRM (2001)
- Uses deflection reduction to a tolerable level
- Design for HMA overlay thickness based on TI and existing HMA layer thickness
- Check also for reflective cracking and ride quality

Caltrans Practice – Overlays
- When RAC-G is used as overlay material
  - Design for conventional HMA thickness
  - Determine RAC-G overlay thickness according to FPRM
    - Table 3 – Based on structural equivalencies
    - Table 4 – Based on reflection crack retardation
  - RAC-G overlay thickness generally half that of the HMA overlay thickness
2005 Study

- Use of RAC in new pavements?
- Can RAC-G thickness be increased more than 60 mm?
- Does 2:1 thickness reduction for RAC-G provide adequate structural equivalency in overlays?

2005 Study

- Joint effort between Caltrans, UC-PPRC, and MACTEC
- Both new pavements and structural overlays
- Laboratory tests (Cohesiometer)
- Theoretical (M-E) analysis with lab-developed models

Primary Findings – New Pavements

- Limited cohesiometer test results indicate that G_f for RAC and HMA are similar.
Primary Findings – New Pavements

- Theoretical analyses did not show structural benefit for the use of RAC-G of same thickness as HMA.
- This is due, in part, to the lower stiffness (higher strains) which offsets the improved fatigue life and which may cause concerns of rutting in the subgrade soil.

Recommendations – New Pavements

- RAC should be treated the same as HMA for new construction.
  \[(G_f)_{RAC} = (G_f)_{HMA}\]
- Caltrans thickness design provides a minimum structural capacity required for the design conditions. It should NOT be reduced when RAC mixes are used.

Primary Findings – Structural Overlays

- Based on M-E analysis, the structural benefit of the RAC-G overlay varies with the thickness placed. The greatest benefit occurs in a thin layer of 30 mm to 60 mm thick as compared to HMA of the same thickness.
- The use of reduced thickness for RAC-G overlay is valid; however, not to the extent previously employed by Caltrans.
Simplified Overlay Thickness Design Charts

Recommendations – Structural Overlays

- Calculate GE for HMA using current methodology and determine structural overlay
- Design RAC-G overlay in a range of 30 to 60 mm to achieve most structural benefit

Revised Practice – New Pavements

- HDM and AR Guide are currently being updated to include information contained in the memo dated 4/24/06 by Caltrans
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  - Mehdi Parvini, Division of Design (916-227-5846)
### RAC Usage in New Pavements

<table>
<thead>
<tr>
<th>Material Type</th>
<th>Max Thickness</th>
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<tbody>
<tr>
<td>RAC-G</td>
<td>60 mm</td>
</tr>
<tr>
<td>RAC-O</td>
<td>45 mm</td>
</tr>
<tr>
<td>RAC-O on RAC-G</td>
<td>45 mm on 60 mm</td>
</tr>
</tbody>
</table>
Revised Practice – New Pavements

- Place on top of conventional HMA or PCC. Do not place directly over aggregates bases (treated or non-treated), subbases, or native soils.
- Place gap-graded RAC (RAC-G) no thicker than 60 mm and open-graded RAC (RAC-O) no thicker than 45 mm. Up to 45 mm of RAC-O may be placed on top of 60 mm of RAC-G.

Revised Practice – New Pavements

- Do not place underneath conventional HMA or open graded friction course (open-graded HMA).
- Do not reduce the overall pavement thickness when RAC is used. Pavement thicknesses for rehabilitation can be reduced with RAC for reflective cracking only. Reflective cracking is not an issue for new construction.

Revised Practice – New Pavements

- Place RAC at the temperature specified in Standard Special Provisions. The project engineer should determine this by verifying with the District Materials Engineer and Resident Engineer that these temperatures will exist during the season and times (traffic lane closures) the Contractor will be performing this work. RAC in thin layers can be more sensitive to lower temperatures.
Revised Practice – Overlays

- Overlay design procedure is now incorporated into new HDM
- Rehabilitation strategies are divided into three categories:
  - Overlay
  - Mill and Overlay
  - Remove and Replace
- Rehabilitation designs are governed by one of the following three criteria:
  - Structural adequacy
  - Reflective cracking
  - Ride quality

Revised Practice – Overlays

- Overlay procedures for flexible over existing flexible pavement
  - Structural adequacy
    - Principle of reducing deflection to a tolerable level is still the basis
    - The required overlay thickness is determined by dividing gravel equivalency (GE) by gravel factor (Gf)
  - Reflective cracking (table for equivalencies)
  - Ride quality (evaluated based on the pavement’s smoothness)

Layer Thickness Equivalencies for Reflective Crack Retardation

<table>
<thead>
<tr>
<th>HMA</th>
<th>RAC-G</th>
<th>RAC-G on SAMI-R</th>
</tr>
</thead>
<tbody>
<tr>
<td>45 mm</td>
<td>30 mm</td>
<td></td>
</tr>
<tr>
<td>60 mm</td>
<td>30 mm</td>
<td></td>
</tr>
<tr>
<td>75 mm</td>
<td>45 mm</td>
<td></td>
</tr>
<tr>
<td>90 mm</td>
<td>45 mm</td>
<td></td>
</tr>
<tr>
<td>105 mm</td>
<td>45 mm</td>
<td></td>
</tr>
</tbody>
</table>

Note: CW = Crack Width

- ≤ 45 mm, if CW ≤ 3 mm
- 60 mm, if CW ≥ 3 mm
- 45 mm, if CW ≥ 3 mm and underlying material is CTB, LCB, or PCC
- ≤ 45 mm, if CW < 3 mm
- 30 mm, if CW ≤ 3 mm
- N/A for CW < 3 mm
- 45 mm, if CW ≥ 3 mm and underlying material is untreated
- 45 mm, if CW ≥ 3 mm and underlying material is CTB, LCB, or PCC
RAC Project Selection – New Pavements
- RAC may be used as final lift of the surface layer for structural purposes, but thickness must be ≤ 60 mm
- If RAC is used to replace a portion of the structural layer, M-E analysis may be used to ensure that fatigue cracking criteria and subgrade cover requirements are satisfied
- RAC may also be used as a non-structural wearing course layer (thickness ≤ 60 mm)

RAC Project Selection – Overlays
- Overlay projects are the best candidates for the use of RAC mixes because existing pavement helps satisfy cover requirements
- If existing pavement is structurally sound and surface cracking is the predominant distress, RAC-G thickness may be reduced up to half of the designed HMA thickness for controlling reflective cracking

RAC Project Selection – Mill & Overlay with RAC
- Projects in which a certain amount of the existing HMA surface is to be removed and replaced are valid candidates for RAC
- Follow the mill and overlay procedure in HDM, check for:
  - Structural adequacy
  - Reflective cracking
  - Ride quality (sufficient)
Cost Analysis – Initial Cost

- 2005 unit costs: $65/ton for HMA vs. $80/ton for RAC. Costs will be higher in 2006.
- In general, initial costs are high; however, reduced layer thickness results in lower costs
- Experienced contractors help keep cost of RAC low

Cost Analysis – LCCA

- Available information indicates that RAC is (in general) cost-effective in the majority of cases when compared to conventional HMA rehabilitation and maintenance strategies.

Cost Analysis – LCCA

- Caltrans is currently developing a LCCA procedure based on the RealCost Model developed by FHWA
- Caltrans procedure has typical M&R schedule for California
  - By various climate region (e.g., coast, valley, desert, and mountain) and for Districts
  - By surface type (e.g., HMA, RAC)
  - By M&R design life
Cost Analysis – LCCA

- Caltrans procedure also includes overall rehabilitation construction unit cost for various strategies (e.g., RAC, CAPM 5-year)
- The Caltrans LCCA procedure will be ready for use by the end of June 2006

Summary of Module 2

- Caltrans Practices
- 2005 Study
- Revised Caltrans Practices
- RAC Project Selection
- Cost Analysis

Questions?