NM 44

A Case History of Long-Term Warranted Performance

Richard W. May
PRDI-Mesa
Background

Background

- 4th highest population - 9th highest unemployment
Background

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- Current funding required 27 years to upgrade
Background

- 4th highest population - 9th highest unemployment
- Current funding required 27 years to upgrade
- Future maint & rehab estimate: $16,000/ln mile/year
Timeline

1995 Construction Cost Estimate for widening and rehab: $237 M

FHWA Financing Conceived in April 1997

RFP issued August 29, 1997

Contract signed July 27, 1998

Substantially Completed November 21, 2001

Warranty until November 20, 2021
Scope of Project

- 118 miles of total reconstruction
- 61% on Native American Land
- Limited R-O-W
- 7 bridges
- 393 culverts
- 3 WIM sites
Pre-Bid Phase

◆ VE Meeting - Oct 13, 1998 (30%)
◆ VE Meeting - Jan 19, 1999 (60%)
◆ Pre-Bid Conference - Jan 25, 1999
◆ NMSHTD Technician Certification Program
  ◆ tried to utilize much of state specs to reduce confusion
Pre-Bid Phase

- Not Design-Build >>> Design, Low Bid, Build
- Professional Services Contract with Warranty
  - created uncertainty and apprehension
- Mesa/NMSHTD bids out initial and future work
Warranty Agreement

> “X-Y-Z” terms

- X Years (20)
- Y Traffic (4 million ESAL)
- Z Total Expenditures ($110 million)
Warranty Agreement

> “X-Y-Z” terms

◆ X Years (20)
◆ Y Traffic (4 million ESAL)
◆ Z Total Expenditures ($110 million)

◆ Cost: $6,400 / ln mile / year
◆ Contractor: material & workmanship of specs
◆ Mesa: Transfer of Long-Term Performance Risk
◆ Backed by Surety Bonds

> involved with design, composition, construction
Warranted Condition

Annual, Automated, Measurable, and Objective

- Rut Depth
- Depressions & Shoving
- Crack Width
- Crack Spacing
- Potholes
- Raveling
- Delamination, Bleeding
- IRI Smoothness

> incentive for preventative maintenance
## Traffic

**NM 44**

NMSHTD Traffic Projections

ESAL Forecast for Heavy Commercial Trucks

20-Year Period

<table>
<thead>
<tr>
<th>Location</th>
<th>1997 RFP Cumulative ESAL (millions)</th>
<th>Negotiated Warranty Traffic (millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MP 2.300 to MP 23.439</td>
<td>3.802</td>
<td></td>
</tr>
<tr>
<td>MP 23.439 to MP 63.424</td>
<td>1.878</td>
<td>4.000</td>
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<tr>
<td>MP 67.915 to MP 85.365</td>
<td>2.778</td>
<td>4.000</td>
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<tr>
<td>MP 85.365 to MP 123.195</td>
<td>2.909</td>
<td>4.000</td>
</tr>
<tr>
<td>MP 123.195 to MP 142.785</td>
<td>3.512</td>
<td>4.000</td>
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</table>
### Climate

<table>
<thead>
<tr>
<th>Weather Station</th>
<th>Elevation (feet)</th>
<th>Mile Post</th>
<th>Mean Low Air Temp (°C)</th>
<th>Min</th>
<th>Mean High 7-day Temp (°C)</th>
<th>Max</th>
<th>98% Grade</th>
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<tr>
<td>Corrales</td>
<td>5016</td>
<td>-7</td>
<td>-16.7</td>
<td>-21.1</td>
<td>35.8</td>
<td>38.1</td>
<td>64-16</td>
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<tr>
<td>Bernalillo</td>
<td>5050</td>
<td>0</td>
<td>-19.4</td>
<td>-32.8</td>
<td>37.3</td>
<td>40.0</td>
<td>64-22</td>
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<tr>
<td>Cuba</td>
<td>6905</td>
<td>64</td>
<td>-26.3</td>
<td>-35.6</td>
<td>33.1</td>
<td>36.9</td>
<td>64-28</td>
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<tr>
<td>Cont. Divide</td>
<td>7275</td>
<td>76</td>
<td></td>
<td></td>
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<td>Chaco Canyon</td>
<td>6175</td>
<td>SW114</td>
<td>-26.9</td>
<td>-38.9</td>
<td>35.2</td>
<td>37.0</td>
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<td>Bloomfield</td>
<td>5807</td>
<td>145</td>
<td>-19.7</td>
<td>-27.8</td>
<td>36.1</td>
<td>38.9</td>
<td>64-22</td>
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<td>Farmington</td>
<td>5400</td>
<td>155</td>
<td>-22.5</td>
<td>-36.7</td>
<td>36.9</td>
<td>38.9</td>
<td>64-28</td>
</tr>
</tbody>
</table>

< 13 in. annual precipitation
Range of Soils

Stiff Plastic Clays

Silty Sands
<table>
<thead>
<tr>
<th>Design Section</th>
<th>Begin Mile</th>
<th>End Mile</th>
<th>90% SG</th>
<th>Design Mr (psi)</th>
</tr>
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<tr>
<td>1-1</td>
<td>23.74</td>
<td>25.60</td>
<td>12.0</td>
<td>7,660</td>
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<tr>
<td>1-2</td>
<td>25.60</td>
<td>28.20</td>
<td>24.5</td>
<td>14,598</td>
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<td>1-3</td>
<td>28.20</td>
<td>41.40</td>
<td>13.0</td>
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<tr>
<td>2-1</td>
<td>41.40</td>
<td>53.80</td>
<td>12.0</td>
<td>7,660</td>
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<tr>
<td>3-1</td>
<td>53.80</td>
<td>63.50</td>
<td>11.8</td>
<td>7,521</td>
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<tr>
<td>4-1</td>
<td>64.78</td>
<td>85.00</td>
<td>13.3</td>
<td>8,382</td>
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<tr>
<td>5-1</td>
<td>85.00</td>
<td>97.42</td>
<td>14.3</td>
<td>8,937</td>
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<tr>
<td>6-1</td>
<td>97.42</td>
<td>104.20</td>
<td>13.6</td>
<td>8,548</td>
</tr>
<tr>
<td>6-2</td>
<td>104.20</td>
<td>108.20</td>
<td>21.1</td>
<td>12,711</td>
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<tr>
<td>6-3</td>
<td>108.20</td>
<td>115.00</td>
<td>11.5</td>
<td>7,383</td>
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<tr>
<td>7-1</td>
<td>115.00</td>
<td>120.60</td>
<td>12.1</td>
<td>7,716</td>
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<tr>
<td>7-2</td>
<td>120.60</td>
<td>130.00</td>
<td>18.4</td>
<td>11,212</td>
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<tr>
<td>8-1</td>
<td>130.00</td>
<td>143.00</td>
<td>22.1</td>
<td>13,266</td>
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</tbody>
</table>
Pavement Design

AASHTO
Present
Serviceability
Index, PSI

Traffic, ESAL

Terminal Serviceability

4 million

Traffic, ESAL

0 1 2 3 4 5

Index, PSI
Layered Approach

Where are our potential problems?

Address each specific problem at the most effective location in the system
Resilient Base

More binder, less air

Tensile Strain

More Life

More binder, less air

More Life

N_f
Design Comparisons
Weighted Averages

- AASHTO (R=95%; Pt=3.0) : 13.3”
- AASHTO (R=80%; Pt=3.0) : 10.9”
- AASHTO (R=80%; Pt=2.5) : 9.8”
- NMSHTD (Probabilistic) : 9.4”
- MESA (Layered Analysis) : 9.0”
Final Design Section

- 1.5 in. AC (PG 70-28)
- 2.5 in. AC (PG 70-28)
- 2.5 in. AC (PG 70-28)
- 2.5 in. AC (PG 64-22)
- 4 in. Aggregate Base
- 2.5 in. AC (PG 70-28)
- 4 in. Aggregate Base

- Natural Soil or Embankment Fill or Soil Treatment

- 3.6 m
- 3.6 m
- 2.4 m

Taper / Slope

Shoulder
Goal

OLD : Roller Coaster Roughness w/patches

NEW : Durable, Tough Mat on a Stable Platform
Over-excavation & Borrow
Soil Treatment

Lime, Fly Ash
Bidding Process

- two-stage approach
- edited NMSHTD specs
- plan SY vs. tons
- Pkg 3 - Sundt (6/99)
Bidding Process

- two-stage approach
- edited NMSHTD specs
  - plan SY vs. tons
- Pkg 3 - Sundt (6/99)
- re-engineering effort
  - design, material specs
  - aggregate sources
  - 7 small to 3 large packages
**Bidding Process**

- two-stage approach
- edited NMSHTD specs
  - plan SY vs. tons
- Pkg 3 - Sundt (6/99)
- re-engineering effort
  - design, material specs
  - aggregate sources
  - 7 small to 3 large packages

- Pkg 1-2 : E.L. Yeager Construction (11-4-99)
- Pkg 4,5,6 : FNF Construction (12-14-99)
- Pkg 7,8 : Western Mobile/Lafarge (2-3-00)
RAP

- 800,000 tons generated
RAP

♦ 800,000 tons generated
♦ allowed as an option:
  ♦ substitute for aggregate base
RAP

- 800,000 tons generated
- allowed as an option:
  - substitute for aggregate base
  - shoulder taper
RAP

◆ 800,000 tons generated
◆ allowed as an option:
  ◆ substitute for aggregate base
  ◆ shoulder taper
  ◆ < 30% of AC Base
RAP

- 800,000 tons generated
- allowed as an option:
  - substitute for aggregate base
  - shoulder taper
  - < 30% of AC Base
  - driveways, turnouts
# Construction

## NM 44

### AC Quantities

<table>
<thead>
<tr>
<th>Warranty Segment of Design Section</th>
<th>Number of Lifts</th>
<th>A 1&amp;2</th>
<th>B 3</th>
<th>C 4&amp;5&amp;6</th>
<th>D 7&amp;8</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Asphalt Concrete (tons of mix)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surface Course</td>
<td>1</td>
<td>100,079</td>
<td>29,980</td>
<td>176,297</td>
<td>95,120</td>
<td>401,476</td>
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<tr>
<td>Binder Course</td>
<td>2</td>
<td>346,294</td>
<td>111,712</td>
<td>574,876</td>
<td>317,058</td>
<td>1,349,940</td>
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<tr>
<td>Base Course</td>
<td>1</td>
<td>128,528</td>
<td>57,885</td>
<td>245,559</td>
<td>122,488</td>
<td>554,460</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>4</td>
<td>574,901</td>
<td>199,577</td>
<td>996,732</td>
<td>534,666</td>
<td>2,305,876</td>
</tr>
</tbody>
</table>

| **Asphalt Binder (tons of liquid)**|         |       |     |          |       |       |
| PG 70-28                          | 3        | 25,634 | 7,428 | 41,293   | 22,706 | 97,061 |
| PG 64-22                          | 1        | 7,069  | 3,010 | 13,495   | 6,738  | 30,312 |
| **Total**                          | 4        | 32,703 | 10,438 | 54,788   | 29,444 | 127,373 |

*Need for over 1 million tons of Aggregate Base*
# NM 44 Pay Factors and Acceptance Tolerances

**Based on Percent Within Limits (PWL)**

<table>
<thead>
<tr>
<th>AC Lift</th>
<th>Surface Course</th>
<th>Binder/Base Course</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Accept %</td>
<td>Accept %</td>
</tr>
<tr>
<td>%</td>
<td>% in</td>
<td>%</td>
</tr>
<tr>
<td>in</td>
<td>in</td>
<td>in</td>
</tr>
<tr>
<td>Pay Factor Item</td>
<td>Tolerance</td>
<td>Total PWL</td>
</tr>
<tr>
<td>-----------</td>
<td>------------</td>
<td>------------</td>
</tr>
<tr>
<td>P 4.75 mm</td>
<td>+/- 5</td>
<td>5</td>
</tr>
<tr>
<td>P 0.6 mm</td>
<td>+/- 4</td>
<td>5</td>
</tr>
<tr>
<td>P 0.075 mm</td>
<td>+/- 1.5</td>
<td>5</td>
</tr>
<tr>
<td>Density (% Gmm)</td>
<td>92 - 96</td>
<td>45</td>
</tr>
<tr>
<td>Thickness</td>
<td>Design - 10</td>
<td>15</td>
</tr>
<tr>
<td>Smoothness</td>
<td>&lt; 5 in./miles</td>
<td>25</td>
</tr>
</tbody>
</table>

*Total Thickness within 0.5 in. of Design*
## PWL Results

### Table: PWL Results

<table>
<thead>
<tr>
<th>Warranty Segment</th>
<th>Number of Lots</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>Total/Avg Project</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PWL Range</td>
<td>1&amp; 2</td>
<td>3</td>
<td>4&amp; 5&amp; 6</td>
<td>7 &amp; 8</td>
<td></td>
</tr>
<tr>
<td>P 4.75 mm</td>
<td># Lots &lt; 60</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>P 0.6 mm</td>
<td># Lots &lt; 60</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>P 0.075 mm</td>
<td># Lots &lt; 60</td>
<td>6</td>
<td>5</td>
<td>3</td>
<td>2</td>
<td>16</td>
</tr>
<tr>
<td>AC Density</td>
<td># Lots &lt; 60</td>
<td>10</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>13</td>
</tr>
<tr>
<td>AC Thickness</td>
<td># Lots &lt; 60</td>
<td>4</td>
<td>0</td>
<td>7</td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td>Surf Smoothness</td>
<td># Lots &lt; 60</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>

| Total            | Total # Lots  | 1255  | 488   | 2055  | 1156  | 4954              |
|                  | % Lots => 90  | 72.9  | 82.2  | 73.2  | 83.4  | 77.9              |
|                  | 75 < % Lots < 89 | 15.4 | 12.3  | 18.8  | 11.4  | 14.5              |
|                  | 60 < % Lots < 74 | 10.1 | 3.7   | 7.3   | 4.2   | 6.3               |
|                  | % Lots < 60    | 1.59  | 1.84  | 0.68  | 1.04  | 1.06              |
|                  | # Lots < 60    | 20    | 9     | 12    | 12    | 53               |
R&R Decisions

- managing schedule, costs, long-term quality
- **not automatic** remove & replace
  - engineering judgement (gradation, high density)
  - laboratory performance testing (compared to design)
  - ‘work-arounds’ (thickness)
- **warranty agreement unchanged**
Smooth Hot Surface Joints
Field Challenges

- Cold Weather
  - AC Base (> 45 F)
  - PMAC (> 55 F)
  - Option to pre-heat up to 200 F
  - Specs met during cold paving
Field Challenges

◆ Traffic Shifting
  ◆ no traffic prior to 4 lifts?
  ◆ 5-mile NO-construction zones?
◆ MOU
◆ maintain traffic safely, accelerate paving schedule, clean surface
Sulfate Reaction Heaving

- Potentially 18 miles
- Ca-based additives
- Water-activated
Results: < 500 feet since opening to traffic

How addressed...

- mill humps
- maintain drainage
Public Relations

- involved local businesses (1400)
- update/employ area residents
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- single focal point w/NMSHTD
- “Eye on the Road” - 5000
- Web Site & ‘1-800’
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- job forums
- training programs

1998

2001
Public Relations

- involved local businesses (1400)
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- job forums
- training programs
- replaced memorials
Public Relations

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- “Eye on the Road” - 5000
- Web Site & ‘1-800’
- job forums
- training programs
- replaced memorials
- ribbon-cutting
Summary

- Reconstructed 118 miles
- June 4, 1999 to November 21, 2001
- Cost: $215 million
- 4 Warranty Segments (IRI: 51 - 65)
The End

Questions ??