Precast Concrete for State-of-the-Art Pavement Infrastructure Maintenance

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Concrete Pavement Infrastructure Maintenance

- Challenges
- Distresses & Traditional Strategies
- Alternative Strategies & Benefits
- Precast Concrete Slabs
- Installation & Innovations
- Summary
- Questions
Challenges

• Aging Infrastructure
  – > 40 years in service

• Heavy Traffic
  – > 50 million ADT, > 10% trucks

• Worker Exposure

• Short & Limited Traffic Closure Periods
  – Daytime peaks from 6 AM – 10 AM, 3 PM – 7 PM allow moving closures off-peak
  – Night time closures from 10 PM – 5 AM
Challenges

• **Limited Budgets & Increasing Costs**
  – Operating costs of equipment, fuel
  – Materials on hand, purchase orders
  – Personnel hours, overtime

• **Durable, Temporary & Emergency Repairs**
  – How long should it last?
  – Days, Months or Years?

• **Willingness to Innovate**
Distresses & Traditional Strategies

• Step-Faulting
  – Grinding, Dowel Bar Retrofit

• Spalling
  – Patching - cold mix, hot mix, cement grouts, polymer resins

• Base Erosion
  – Subsealing – cement grout, urethane foam
FIGURE 1 Existing failing pavement condition on Route 210 near Montrose, CA
Distresses & Traditional Strategies

• **Cracking**
  – Crack sealing – bituminous, silicone, methacrylate, epoxy
  – Slab Replacement – hot mix, concrete mix

• **Most** distresses lead to eventual slab replacement
• **Not all** repair strategies are effective\(^1\)
Alternative Strategies & Benefits

• Looking for longer lasting alternatives
  – High Early Strength Concretes
  – Precast Concrete$^2$
• Work completed in shorter windows
• Open to traffic sooner
• Fewer repairs reduces worker exposure
• Cost of durable repairs
  – Potential higher initial cost
  – Potential lower long term / life-cycle costs
Example: Cost of durable repairs

- **Traditional Portland Cement Slab replacement**
  - Cost $2500 per slab
  - Open to traffic in 10 days
  - Lasts 10+ years, can be reused for aggregate

- **Portland Cement Slab Replacement (accelerated mix)**
  - Cost $2500 per slab
  - Open to Traffic in > 4 to 10 hours
  - Lasts 2 to 5 years, can be reused for aggregate
Example: Cost of durable repairs

- **Sulfo-Aluminate (Belite) Cement Slab Replacement**
  - Cost $2500 - $3500 per slab
  - Open to Traffic in > 1 to 4 hours
  - Lasts > 15+ years, can be reused for aggregate

- **Precast Concrete Slab Replacement**
  - Cost $2500 - $3500 per slab
  - Open to Traffic in >1 to 3 hours
  - Lasts 20 – 40+ years, can be salvaged & reused as a precast panel elsewhere

13 – Figure 2
Durable vs. Temporary & Emergency Repairs

• **Durable repairs**
  – Last longer
  – Need fewer repairs over time
  – Cost less over time
  – Reduce worker exposure over time

• **Temporary Repairs**
  – Need to open quickly
  – Need to last until they can be replaced
  – Uncertain durability may require repeated repairs
  – Increase in worker exposure due to repeated repairs
  – Uncertain costs due to repeated repairs
Durable vs. Temporary & Emergency Repairs

- Emergency Repairs
  - Usually during adverse weather & traffic
  - Must open quickly
  - Similar to temporary repairs
    - Need to last until they can be replaced
    - Uncertain durability may require repeated repairs
    - Increase in worker exposure due to repeated repairs
    - Uncertain costs due to repeated repairs

What if...
- Could it be possible to get durability too?
Precast Concrete Pavement

• **Durable**\(^2, 3, 4, 5\)
  – Fabricated in controlled plant
  – HVS testing of >150 million ESALS with no distress, 240 million ESALS to failure\(^4, 5\)

• **Open to Traffic Quickly**
  – 300 lane-feet in 3 hours, near Lake Hughes Road, I-5
  – 375 lane-feet in 3 hours, near Peck Road, I-10

• **Adverse weather installation**
  – Near Lincoln Ave, Altadena, I-210 – light drizzle
  – Near Lake Hughes Road, Castaic, I-5 – 34\(^\circ\) (near freezing) temperature
Precast Concrete Slabs

• **Used in many applications**
  – Individual pavement slabs, I-101, I-210, etc.
  – Pavement lanes, I-5, I-10, I-101, I-210, etc.
  – Bus pads, LA-2, Santa Monica Bl., Hollywood, CA
  – Intersections
  – Curved alignments, I-101 @ LA-170 IC connector

• **Installation**
  – Contractor purchase order
  – Maintenance forces
  – Competative bid contracts, etc.
Precast Concrete Slabs

• Reduced thickness
  – Reinforcing &/or pre-stress for in-kind thickness & handling stresses

• Reusable
  – Panels from I-15 in District 8 were salvaged and reused on another project.
  – Can be stockpiled for emergency and temporary use
  – Panels on I-210 near Monrovia used as temporary roadway during construction.
# Pavement Depth vs. Traffic Loading, in ESALS*

<table>
<thead>
<tr>
<th>PAVEMENT THICKNESS</th>
<th>EQUIVALENT SINGLE AXLE LOAD (California Coastal Climate)</th>
<th>EQUIVALENT SINGLE AXLE LOAD (California Inland Valley Climate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8” (20 cm)</td>
<td>&lt; 800,000 ESALS</td>
<td>-</td>
</tr>
<tr>
<td>9” (22.5 cm)</td>
<td>3,020,000 ESALS</td>
<td>&lt; 800,000 ESALS</td>
</tr>
<tr>
<td>10” (25 cm)</td>
<td>13,500,000 ESALS</td>
<td>6,600,000 ESALS</td>
</tr>
<tr>
<td>12” (30 cm)</td>
<td>84,700,000 ESALS</td>
<td>26,100,000 ESALS</td>
</tr>
<tr>
<td>14” (35 cm)</td>
<td>238,000,000 ESALS</td>
<td>84,700,000 ESALS</td>
</tr>
<tr>
<td>16” (40 cm)</td>
<td>-</td>
<td>238,000,000 ESALS</td>
</tr>
</tbody>
</table>

* TABLE 1 Capability of Existing Pavement Depth to Support Traffic Loading, in ESALS*
FIGURE 2 Salvaged precast pavement on Route 15, San Bernardino, CA.
Installation Details

• **Identify damaged panels**
  – Measure for typical size, depth, geometry
  – Submit requirements to contractor or fabricator

• **Demolition**
  – Sawcut pavement to fit panel
  – Recommend non-impact removal to reduce base preparation, save time & materials

• **Base preparation**
  – Recommend treated base to prevent base erosion
FIGURE 3  Base preparation of precast pavement installation on Route 210 near Montrose, CA.
FIGURE 4  Constructing rapid setting lean concrete base on Route 680 in Dublin, CA.
FIGURE 5 Saturated sub-grade condition under precast pavement.
Installation Details

• **Panel Preparation**
  - Apply joint filler to sides of panel
  - Insert dowels
  - Apply bond breaker to panel soffit or base surface
    - Spray applied or geotextile
  - Apply grout containment measures
    - Caulk, foam filler, plastic sheeting, etc.
  - Attach / place leveling system
    - Shims, tracks, leveling bolts, leveling beams, etc.
Installation Details

• **Panel Placement**
  – Guide panel into excavation
  – Avoid spalling due to poor handling (bumping & using crowbars)
  – Verify panel is level with adjacent pavement
    • or complies with planned profile
  – Pump in underslab grout to fill any voids
    • Use grout holes to verify grout has filled voids
  – Fill access pockets and dowel slots with approved filler material
  – Remove surface hardware before opening to traffic
FIGURE 6  Installation of precast pavement on Route 210 near Montrose, CA
Panel Innovations

• Repeatability
  – Leads to improvements & optimization

• Leveling Devices
  – Shims, leveling bolts & hardware
    • Sacrificial
    • Underslab grout must set before opening to traffic
  – Leveling beams & brackets
    • Reusable
    • Underslab grout must set before removing and opening to traffic
  – Accurate base preparation
    • May not require leveling hardware
    • May not need underslab grout
FIGURE 7 Precast pavement and hot-mix-asphalt taper used for temporary pavement on a truck lane near Sylmar, CA.
Panel Innovations

• Load Transfer Devices
  – Smooth round pavement dowels
    • Surface slots, downward slots, embedded sleeves
    • Dowel Grout
  – Keyed Joints
    • Key & keyway with epoxy bond
    • Double key - grouted

• Curved Panels
  – Trapezoidal or wedge shapes
  – Folded PCI or Warped Panels

13 – Figure 9
Fort Miller
FIGURE 8  Panels installed with proprietary leveling and load transfer devices at Route 10 Banning truck scales, Riverside, CA.
FIGURE 9 Precast pavement installed on a curve on Route 101 near Studio City, CA.
Panel Innovations

• **Durability Testing**
  – **Heavy Vehicle Simulator** \(^4, 5\)
    • Accelerated testing to 150 million ESALS with no panel distress
    • Granular base pumped out
    • Accelerated testing with extra heavy load to 240 million ESALS failed by crushing
  – **Falling Weight Deflectometer**
    • Measures load transfer efficiency
    • Multiple “drops” can demonstrate accelerated loading.
FIGURE 10  Falling weight deflectometer testing (FWD) of a proprietary load transfer device at Route 10 Banning truck scales, Riverside, CA.
Summary

• Concrete pavement infrastructure maintenance crews face many challenges
  – Aging infrastructure
  – Heavy traffic demands quick repairs due to limited closure periods
  – Worker exposure increases with repeated failures
  – Need for durable repairs due to limited budgets & increasing costs
  – Limited repair strategies beg for innovative solutions
Summary

- Precast Concrete pavement offers many solutions to the challenges
  - Durability 2, 3, 4, 5 reduces worker exposure and cost of repeated repairs
  - Opens to traffic quickly, even in adverse weather conditions
  - Reduced thickness reduces time and cost of repairs
  - Many applications, including emergency & temporary repairs
  - Reusability reduces costs, improves sustainability
  - An innovative tool for State-of-the-Art Pavement Infrastructure Maintenance
FIGURE 11 Precast pavement to replacements ready to open to the morning commuter, on Route 10, in Los Angeles, CA.
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References


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