PRECAST CONCRETE PAVEMENT FOR AIRPORTS

SWIFT 2017 - Chris Olidis, P.Eng.
With grateful acknowledgement to Shiraz Tayabji
PRESENTATION OUTLINE

- Pavement Damage - Structural
- Typical Repair Methods
- Alternative Repair Method – Precast Panels
- Background
- Applications
- Design Considerations
Portland cement concrete (PCC) pavement is not indestructible

PCC damage can include:

- Slab cracking
- Shattered slabs
- Corner breaks
- Joint spalling
WHY IS THIS A PROBLEM?

- Loss of serviceability
- Reduced structural performance
- Can generate foreign object damage (FOD)
TRADITIONAL REPAIR METHOD

- Full depth repair and/or slab replacement
- Conventional PCC
  - Similar properties to original PCC
  - Generally good performance
  - Long curing period
- High early PCC
  - Availability to aircraft in a few hours
  - Can have durability issues
SLAB REPLACEMENT

- The most common repair technique
- Remove damaged slab
SLAB REPLACEMENT

- Re-grade and compact substrate
SLAB REPLACEMENT

- Install load transfer devices
SLAB REPLACEMENT

- Place and cure concrete
TRADITIONAL SLAB REPLACEMENT

- Repair with conventional concrete:
  - High level of durability and long service life
  - Must achieve minimum strength for traffic availability
    - Minimum 14 days without testing confirmation
- Repair with fast track / high early concrete
  - Can traffic aircraft within hours
  - Reduced durability and service life not uncommon
ALTERNATIVE REPAIR METHOD

- Precast Concrete Slabs
PRECAST PAVING BACKGROUND

- Early soviet trials in the 1930/1940’s
- Increased North American use since the 1990’s
- Used primarily for rapid repair & rehabilitation
- Panels fabricated off-site, transported to project site & installed on a prepared foundation
- Advantageous for night work & short work windows
PRECAST PAVING BACKGROUND

- Highway experience is more extensive
  - Smaller slab sizes easier to work with

- Airfield usage includes:
  - Calgary International Airport
    - Early 1990’s – 13 slabs
  - LaGuardia Airport
  - Washington Dulles International Airport
ADVANTAGES OF PRECAST

- Better control of material quality
  - Manufactured under controlled conditions
  - Conventional concrete mixes
  - Slabs are reinforced
  - May be pre-stressed
ADVANTAGES OF PRECAST

- Fabricated in advance and stored until needed
  - Panel size must be predictable
- Less sensitive to weather conditions
  - Field curing not required – hot and cold extremes
  - Rain damage not an issue
DISADVANTAGES OF PRECAST

- Higher cost
  - Significantly higher than conventional cast in place
  - Higher than fast track

- Size and weight of panels
  - Specialized equipment (cranes, etc) required

- Specialized crews for lifting, leveling, and grouting
APPLICATIONS

- Single and multiple slab replacement
  - Nominally reinforced panels (common)
  - Pre-stressed panels (typically longer/wider panels)
SINGLE SLAB REPLACEMENT

- Replacement of one panel only or partial panel
- Can be considered for a number of applications including
  - replacement of a shattered slab
  - full depth crack repair
  - full depth joint repairs
SINGLE SLAB REPLACEMENT

All precast repair panels are 18 feet x 9 feet

18 feet 18 feet 18 feet

All precast repair panels are 18 feet x 9 feet
MULTIPLE SLAB REPLACEMENT

<table>
<thead>
<tr>
<th>18 feet</th>
<th>18 feet</th>
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<tbody>
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<td>18 feet</td>
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</table>

All precast repair panels are 18 feet x 9 feet
## PRECAST SYSTEMS

<table>
<thead>
<tr>
<th>Method</th>
<th>Load transfer</th>
<th>Base support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fort Miller Super-Slab®</td>
<td>Dowels inserted into the existing pavement</td>
<td>Manufactured sand followed by grouting</td>
</tr>
<tr>
<td>Michigan</td>
<td>Dowels cast into the precast panel</td>
<td>Flowable fill</td>
</tr>
<tr>
<td>URETEK</td>
<td>Fibreglass ties inserted after the precast panel is placed</td>
<td>Grouting using injected polyurethane foam</td>
</tr>
<tr>
<td>California Barra Glide system</td>
<td>Dowels ‘slide into receiving hole</td>
<td>Flowable grout and leveling plates</td>
</tr>
<tr>
<td>Other</td>
<td>Various modifications</td>
<td>Any of the above</td>
</tr>
</tbody>
</table>
Existing Slab  |  Precast Panel  |  Existing Slab

Existing Base

Prepared bedding (Granular or flowable concrete)
FORT MILLER SYSTEM

[Images of various construction elements and workers involved in the installation process.]

[Logo of ARA in the bottom right corner.]
FORT MILLER SYSTEM

- Load transfer – bottom slot system
FORT MILLER - BASE PREP

- 1st night
- Thin granular layer to set base grade
- Leveled with a screed
- Form release agent to prevent dowel grout bond
FORT MILLER - PLACEMENT

- 1st night
- Set panels
FORT MILLER – GROUTING

- 2\textsuperscript{nd} night
- Inject flowable bedding grout
- Inject dowel grout
MICHIGAN METHOD
MICHIGAN METHOD

- Load transfer – top slot system

- Dowel bar
- Epoxy coated bar
- Existing slab
- Base
- 1/2
- Hot-poured rubberized asphalt sealant
- Precast panel
- Compressible material
- Flowable fill
- Proprietary concrete repair material
- Subgrade
MICHIGAN - BASE PREP

- Cementitious self-levelling flowable fill
Method modified by US Air Force for rapid theater of operation use
URETEK METHOD

- Precast panels with no dowels
- High density polyurethane foam to lift and level slab
- Fibreglass ties to restore load transfer
BASIC CONCEPT – LEVELING BOLTS
CASE STUDY – LAGUARDIA TAXI D-D

- Opened in 1939
- Congested taxiways
- Flexible pavement has grown thick
- Premature rutting issues

Courtesy of Scott Murrell
LAGUARDIA - CONSTRUCTION

- Mill existing pavement (100 ft x 50 ft)
- Set steel bearing plates
- Install panels (12.5 ft x 25 ft, 16 in thick)
- Inject grout
- Fill dowel slots
- Joint seal and pavement marking
- Completed over a 36 hour weekend closure
Milling of Existing Asphalt Concrete Pavement
(7:00 AM to 2:00PM)
Installation of Steel Bearing Plates
(2:00PM to 7:00PM)
Installation of Precast Concrete Panels
(7:30PM to 2:30AM)
Installation of Precast Concrete Panels (continued)
Installation of Cement Grout Bed
(3:00 AM to 12:00 PM)
Installation of Cement Grout Bed (continued)
Dowel Slots Filled with Concrete
Joint Sealing, Pavement Markings and Asphalt Paving (12:30 PM to 7:30 PM)
DESIGN CONSIDERATIONS

- Precast Panel must be slightly undersized
DESIGN CONSIDERATIONS

- Panel Handling
  - 4 point lift required
  - Lifting hardware left in place must have 70 mm top cover and 50 mm bottom cover after installation
  - PCI provides guidance on lift anchor locations
## PANEL WEIGHT

<table>
<thead>
<tr>
<th>Panel Size (ft)</th>
<th>Panel Thickness (in.)</th>
<th>Panel Weight (lb)</th>
<th>Four-Point Lift Anchor Load (Static) (lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 x 6</td>
<td>8</td>
<td>7,000</td>
<td>1,750</td>
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<tr>
<td></td>
<td>10</td>
<td>8,700</td>
<td>2,175</td>
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<tr>
<td></td>
<td>12</td>
<td>10,400</td>
<td>2,600</td>
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<tr>
<td>12 x 12</td>
<td>8</td>
<td>13,900</td>
<td>3,500</td>
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<td></td>
<td>10</td>
<td>17,300</td>
<td>4,325</td>
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<tr>
<td></td>
<td>12</td>
<td>20,800</td>
<td>5,200</td>
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<tr>
<td>12 x 15</td>
<td>8</td>
<td>17,300</td>
<td>4,325</td>
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<td>10</td>
<td>21,600</td>
<td>5,400</td>
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<td></td>
<td>12</td>
<td>26,000</td>
<td>6,500</td>
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<tr>
<td>12 x 20</td>
<td>8</td>
<td>23,100</td>
<td>5,775</td>
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<tr>
<td></td>
<td>10</td>
<td>28,800</td>
<td>7,200</td>
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<tr>
<td></td>
<td>12</td>
<td>34,600</td>
<td>8,650</td>
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<td></td>
<td>8</td>
<td>41,500</td>
<td>10,375</td>
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<tr>
<td>12 x 36</td>
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<td>51,900</td>
<td>12,975</td>
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<td>12</td>
<td>62,200</td>
<td>15,550</td>
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### STATIC LIFTING FLEXURAL STRESSES

<table>
<thead>
<tr>
<th>Panel Length (ft.)</th>
<th>Panel Width (ft.)</th>
<th>Panel Thickness (in.)</th>
<th>Maximum Concrete Lifting Stress (psi)</th>
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<tbody>
<tr>
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<td>12</td>
<td>9</td>
<td>39</td>
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<td>24</td>
<td>9</td>
<td>154</td>
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<td>36</td>
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*As a panel dimension gets longer, pretensioning becomes necessary.*

*PCI guidelines (PCI 2004)*
SELECT REFERENCES
Questions ?