ACI 330R-08
The Gold Standard for Concrete Parking Lot Design

Greg Novitzki, P.E., LEED A.P.
New York Construction Materials Association
Who is NYMMaterials?

The New York Construction Materials Association
Represent the construction material producers of New York

Concrete  Blacktop  Aggregate
Learning Objectives

- Be able to identify the best design methodology for concrete parking lots
- Gain a better understanding of the need and appropriateness of a subbase course under concrete parking lots
- Understand what information about the project is necessary for the parking lot design
- Recognize that the contractor is not the best choice for the design and layout of the jointing plan
- Confidently prepare a specification for the construction of a concrete parking lot
Sites in Rochester & Buffalo Area

Cattaraugus, NY
Sustainability

- Reducing the Heat Island Effect
- Energy Efficiency
- Lighting Efficiency
- Safety
- Durability
- Storm Water Management
Building Material Prices: Advantage Concrete

![Producer Price Indices - Concrete Vs. Asphalt](image)

(2002 = Base)
ACI 330R-08
The Gold Standard for Concrete Parking Lot Design

• Goals:
  1) Why use ACI 330?
  2) Basic elements of ACI 330R-08
  3) To magnify need to use ACI 330 over standard AASHTO practice
What Is It?

- 330R-08 : Guide (Design AND Construction)
- 330.1-03 : Specification
Why Use It?
### 4.6.1 Design Recommendations

<table>
<thead>
<tr>
<th>Traffic Area</th>
<th>Bituminous Concrete Wearing Course (inches)</th>
<th>Bituminous Concrete Binder Course (inches)</th>
<th>Portland Cement Concrete Base (inches)</th>
<th>Granular Base Subbase (inches)</th>
<th>Total Thickness (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy Duty</td>
<td>1.5</td>
<td>2.0</td>
<td>N/A</td>
<td>6</td>
<td>15.5</td>
</tr>
<tr>
<td>Rigid</td>
<td>N/A</td>
<td>N/A</td>
<td>6</td>
<td>6</td>
<td>18</td>
</tr>
<tr>
<td>Standard Duty</td>
<td>1.5</td>
<td>1.5</td>
<td>N/A</td>
<td>6</td>
<td>15</td>
</tr>
<tr>
<td>Heavy Duty</td>
<td>1.5</td>
<td>1.5</td>
<td>N/A</td>
<td>6</td>
<td>15.5</td>
</tr>
</tbody>
</table>

Pavement designs were based on the *AASHTO Guide for Design of Pavement Structures (1993)* and our experience with similar projects. The thickness of each course is a function of subgrade strength, traffic, design life, serviceability factors. Frost susceptibility is a major factor in the overall pavement section thickness. The design of pavement thickness was based on the following:

- 11,000 18-kip Equivalent Axle Loads (EALs) for standard-duty parking lot
- 30,000 18-kip EALs for heavy-duty driveways and truck access lanes
- Soil characterization of “fair”, based on the encountered subsurface conditions
- Design life of 20 years

Pavements subjected to high traffic volumes and heavy trucks require thicker pavement sections. Rigid concrete pavement is recommended at the location of dumpsters where refuse trucks will park, areas of channelized traffic, and loading areas. For dumpster pads, as a minimum, the concrete pavement area should be large enough to support the container and the entire length of the refuse truck. Concrete pavements should be reinforced and have relatively closely spaced control joints, approximately 10- to 12-foot spacing. We recommend the concrete reinforcement consist of 6x6-W2.0xW2.0 welded wire or equivalent. Dowels should be provided across slab expansion joints to limit differential settlements. The outer edges of the concrete pavement are susceptible to damage as trucks move from the concrete to the adjacent bituminous concrete. Therefore, the concrete thickness of the outer 2 feet of the concrete pavement should be increased to 12 inches. Concrete pavements should be protected from construction traffic until a compressive strength of at least 2,500 psi has been achieved. The above sections represent minimum thicknesses and, as such, periodic maintenance should be anticipated.

Granular subbase should be compacted to at least 95 percent of the maximum dry density determined by ASTM D1557, Method C. The bituminous concrete should be placed in accordance with the *New York State Department of Transportation (NYSDOT) Standard Specifications (Amended January 2012)*. Bituminous concrete should be placed within the temperature range specified therein and compacted to between 92.5 and 97.5 percent.
The AASHO road test and AASHTO method

AASHTO design equations:

- Empirical
- Use the “ESAL” concept
- Developed Serviceability Factors

\[
\text{Log(ESALs)} = Z_{R} \cdot s_{o} + 7.35 \cdot \text{Log}(D + 1) - 0.06 + \frac{\text{Log} \left( \frac{\Delta \text{PSI}}{4.5 - 1.5} \right)}{1 + 1.624 \times 10^{7} (D + 1)^{8.46}} + (4.22 - 0.32p_{t}) \cdot \text{Log} \left( S'_{c} \cdot C_{d} \cdot \left[ D^{0.75} - 1.132 \right] \right) \]

\[
215.63 \cdot \text{Load Transfer} \cdot \text{Modulus of Elasticity} \left( \frac{E_{c}}{k} \right)^{0.25} - 18.42 \cdot \text{Depth} \cdot \text{Modulus of Subgrade Reaction} \]

\[
\text{Standard Normal Deviate} \quad \text{Overall Standard Deviation} \quad \text{Depth} \quad \text{Change in Serviceability} \quad \text{Terminal Serviceability} \quad \text{Modulus of Rupture} \quad \text{Drainage Coefficient} \quad \text{Load Transfer} \quad \text{Modulus of Elasticity} \quad \text{Modulus of Subgrade Reaction} \]
AASHO Test Traffic

Max Single Axle

Max Tandem Axle
### Comparing Apples to Apples

<table>
<thead>
<tr>
<th>Asphalt</th>
<th>Concrete</th>
</tr>
</thead>
<tbody>
<tr>
<td>3” Asphalt</td>
<td>5” Concrete</td>
</tr>
<tr>
<td>10” Base</td>
<td>Compacted Earth</td>
</tr>
<tr>
<td>Compacted Earth</td>
<td></td>
</tr>
<tr>
<td>4” Asphalt</td>
<td>6.5” Concrete</td>
</tr>
<tr>
<td>12” Base</td>
<td>Compacted Earth</td>
</tr>
<tr>
<td>Compacted Earth</td>
<td></td>
</tr>
<tr>
<td>6” Asphalt</td>
<td>8” Concrete</td>
</tr>
<tr>
<td>12” Base</td>
<td>Compacted Earth</td>
</tr>
<tr>
<td>Compacted Earth</td>
<td></td>
</tr>
</tbody>
</table>
Using ACI 330R-08

- ACI 330 recognizes parking lots are different than a street or roadway.

**Known:**
- Soil Strength
- Concrete Strength
- Traffic Demand

**Determines:**
- Thickness
- Jointing
- Reinforcing (opt.)
- Subbase (opt.)
Overview of the Document:

- Pavement Design – CH 3
- Materials – CH 4
- Construction – CH 5
- Inspection and Testing – CH 6
- Maintenance and Repairs – CH 7
Designing with ACI 330:

Key Terminology:
- $k$ – modulus of subgrade or CBR – California Bearing Ratio
- ADTT – average daily truck traffic
- MOR – modulus of rupture

Table 3.1—Subgrade soil types and approximate support values (Portland Cement Association 1984a,b; American Concrete Pavement Association 1982)

<table>
<thead>
<tr>
<th>Type of soil</th>
<th>Support</th>
<th>$k$, psi/in.</th>
<th>CBR</th>
<th>$R$</th>
<th>SSV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fine-grained soils in which silt and clay-size particles predominate</td>
<td>Low</td>
<td>75 to 120</td>
<td>2.5 to 3.5</td>
<td>10 to 22</td>
<td>2.3 to 3.1</td>
</tr>
<tr>
<td>Sands and sand-gravel mixtures with moderate amounts of silt and clay</td>
<td>Medium</td>
<td>130 to 170</td>
<td>4.5 to 7.5</td>
<td>29 to 41</td>
<td>3.5 to 4.9</td>
</tr>
<tr>
<td>Sand and sand-gravel mixtures relatively free of plastic fines</td>
<td>High</td>
<td>180 to 220</td>
<td>8.5 to 12</td>
<td>45 to 52</td>
<td>5.3 to 6.1</td>
</tr>
</tbody>
</table>

Notes: CBR = California bearing ratio; $R$ = resistance value; and SSV = soil support value. 1 psi = 0.0069 MPa, and 1 psi/in. = 0.27 MPa/m.
Designing with ACI 330:

Table 3.3—Traffic categories*

1. Car parking areas and access lanes—Category A
2. Shopping center entrance and service lanes—Category B
3. Bus parking areas, city and school buses
   Parking area and interior lanes—Category B
   Entrance and exterior lanes—Category C
4. Truck parking areas—Category B, C, or D

<table>
<thead>
<tr>
<th>Truck type</th>
<th>Parking areas and interior lanes</th>
<th>Entrance and exterior lanes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single units (bobtailed trucks)</td>
<td>Category B</td>
<td>Category C</td>
</tr>
<tr>
<td>Multiple units (tractor trailer units with one or more trailers)</td>
<td>Category C</td>
<td>Category D</td>
</tr>
</tbody>
</table>

*Select A, B, C, or D for use with Table 3.4.
## ACI 330R-08 Guidelines – Table 3.4

<table>
<thead>
<tr>
<th>Traffic Category</th>
<th>MOR, psi: $k = 500$ psi/in. (CBR = 50, R = 86)</th>
<th>MOR, psi: $k = 400$ psi/in. (CBR = 38, R = 80)</th>
<th>MOR, psi: $k = 300$ psi/in. (CBR = 26, R = 67)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>650</td>
<td>600</td>
<td>550</td>
</tr>
<tr>
<td>A (ADTT = 1)</td>
<td>4.0</td>
<td>4.0</td>
<td>4.0</td>
</tr>
<tr>
<td>A (ADTT = 10)</td>
<td>4.0</td>
<td>4.0</td>
<td>4.0</td>
</tr>
<tr>
<td>B (ADTT = 25)</td>
<td>4.0</td>
<td>4.5</td>
<td>4.5</td>
</tr>
<tr>
<td>B (ADTT = 300)</td>
<td>5.0</td>
<td>5.0</td>
<td>5.5</td>
</tr>
<tr>
<td>C (ADTT = 100)</td>
<td>5.0</td>
<td>5.0</td>
<td>5.5</td>
</tr>
<tr>
<td>C (ADTT = 300)</td>
<td>5.0</td>
<td>5.5</td>
<td>5.5</td>
</tr>
<tr>
<td>C (ADTT = 700)</td>
<td>5.5</td>
<td>5.5</td>
<td>6.0</td>
</tr>
<tr>
<td>D (ADTT = 700)</td>
<td>6.5</td>
<td>6.5</td>
<td>6.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>$k = 200$ psi/in. (CBR = 10, R = 48)</th>
<th>$k = 100$ psi/in. (CBR = 3, R = 18)</th>
<th>$k = 50$ psi/in. (CBR = 2, R = 5)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>650</td>
<td>600</td>
<td>550</td>
</tr>
<tr>
<td>A (ADTT = 1)</td>
<td>4.0</td>
<td>4.0</td>
<td>4.0</td>
</tr>
<tr>
<td>A (ADTT = 10)</td>
<td>4.5</td>
<td>4.5</td>
<td>5.0</td>
</tr>
<tr>
<td>B (ADTT = 25)</td>
<td>5.0</td>
<td>5.0</td>
<td>5.5</td>
</tr>
<tr>
<td>B (ADTT = 300)</td>
<td>5.5</td>
<td>5.5</td>
<td>6.0</td>
</tr>
<tr>
<td>C (ADTT = 100)</td>
<td>5.5</td>
<td>6.0</td>
<td>6.0</td>
</tr>
<tr>
<td>C (ADTT = 300)</td>
<td>6.0</td>
<td>6.0</td>
<td>6.5</td>
</tr>
<tr>
<td>C (ADTT = 700)</td>
<td>6.0</td>
<td>6.5</td>
<td>6.5</td>
</tr>
<tr>
<td>D (ADTT = 700)</td>
<td>7.0</td>
<td>7.0</td>
<td>7.0</td>
</tr>
</tbody>
</table>
Actual NRMCA National Account Design Situation:

**Requested AASHTO Design Methodology:**
Standard Duty: 7” over 6” subbase
Heavy Duty: 8” over 6” subbase

**Revised Project Criteria using ACI 330 R-08 Guideline:**
Standard Duty: 5” – no subbase
Heavy Duty: 6” over 4” subbase

Substantial Cost Savings !!!
Keeping thickness in perspective...

- “Rules of thumb” work fine for many small projects.
- Actual fatigue failures are rare.
- Most thickness design is conservative for assumed loads.
- More critical issues:
  - Subgrade / subbase uniformity
  - Drainage & maintenance
Common Design Questions?

- Are Subbases Necessary?
- What About Fibers?
- Steel Reinforcement?
- How Important is Jointing?
Subbase Layer?

• In most cases, no.
• May warrant consideration if:
  – Construction platform is needed
  – Subgrade is very poor quality
  – Heavy truck traffic & load transfer concerns
  – Pumping of subgrade is likely
Concrete vs. Asphalt

Subgrade stresses differ considerably.

The load-carrying structure for concrete pavement is primarily thickness.
Adjusted $k$ for subbase (ACI 330R-08)

Table 3.2 – Modulus of subgrade reaction $k^*$

<table>
<thead>
<tr>
<th>Subgrade $k$ value, psi/in.</th>
<th>Subbase thickness</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4 in.</td>
<td>6 in.</td>
<td>9 in.</td>
<td>12 in.</td>
</tr>
<tr>
<td>Granular aggregate subbase</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>65</td>
<td>75</td>
<td>85</td>
<td>110</td>
</tr>
<tr>
<td>100</td>
<td>130</td>
<td>140</td>
<td>160</td>
<td>190</td>
</tr>
<tr>
<td>200</td>
<td>220</td>
<td>230</td>
<td>270</td>
<td>320</td>
</tr>
<tr>
<td>300</td>
<td>320</td>
<td>330</td>
<td>370</td>
<td>430</td>
</tr>
<tr>
<td>Cement-treated subbase</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>170</td>
<td>230</td>
<td>310</td>
<td>390</td>
</tr>
<tr>
<td>100</td>
<td>280</td>
<td>400</td>
<td>520</td>
<td>640</td>
</tr>
<tr>
<td>200</td>
<td>470</td>
<td>640</td>
<td>830</td>
<td>—</td>
</tr>
<tr>
<td>Other treated subbase</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>85</td>
<td>115</td>
<td>170</td>
<td>215</td>
</tr>
<tr>
<td>100</td>
<td>175</td>
<td>210</td>
<td>270</td>
<td>325</td>
</tr>
<tr>
<td>200</td>
<td>280</td>
<td>315</td>
<td>360</td>
<td>400</td>
</tr>
<tr>
<td>300</td>
<td>350</td>
<td>385</td>
<td>420</td>
<td>490</td>
</tr>
</tbody>
</table>
Common Design Questions?

• Steel Reinforcement?
Reinforcement
Simply Supported Beam

Compression in upper half
Tension in lower half
Primary steel reinforcement necessary
Reinforcement
Continuously Supported Beam

- No strain from loads
- No need for primary reinforcement
What about Fibers and WWM?

- What’s their purpose?
  - Steel and Macro Fibers (0.008-0.03”); WWM—Secondary Reinforcement – Tight Cracks!
  - Micro Fibers (<0.004”) – Plastic Shrinkage Crack Control
Plastic Shrinkage Cracks
Secondary Steel Reinforcement

“The use of distributed steel reinforcement will not add to the load-carrying capacity of the pavement and should not be used in anticipation of poor construction practices.”

American Concrete Pavement Association
“When pavement is jointed to form short panel lengths that will minimize intermediate cracking, distributed steel reinforcement is not necessary.”
SHRINKAGE AND CRACKING

Slab + Rollers

Shrinkage + Freedom to move = No cracks

Granular fill

Shrinkage + Subbase restraint = Cracks
Common Design Questions?

• How Important is Jointing?
Proper Jointing is all about:

- Finding the restraint
- Anticipating the Cracks
- Weakening the Slab
Jointing

• Concrete gets harder over time and it cracks....
• Fortunately the cracks are predictable:
  – DAP provides free jointing plans
    Even if we didn’t provide the design
  – Don’t rely on the contractor to lay out the jointing plan
Control Joints

- Sawcut
- Induced crack
- Sawed contraction joint
- Plastic or hardboard preformed strip
- Premolded insert contraction joint

- 1/4 D min.
A “Proper” Crack
### Recommended Spacing

<table>
<thead>
<tr>
<th>Thickness</th>
<th>Spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>4”</td>
<td>8’-10’</td>
</tr>
<tr>
<td>5”</td>
<td>10’-12’</td>
</tr>
<tr>
<td>6”</td>
<td>12’-15’</td>
</tr>
<tr>
<td>7”</td>
<td>14’-15’</td>
</tr>
<tr>
<td>8”+</td>
<td>15’</td>
</tr>
</tbody>
</table>
It Cracks, Where we want it.
Overview of the Document:

- Pavement Design – CH 3
  - Materials – CH 4
  - Construction – CH 5
  - Inspection and Testing – CH 6
  - Maintenance and Repairs – CH 7
Materials

- Flexural Strength – key property
- Freeze/Thaw – Air Entrainment Necessary?
- Well-graded Aggregates
  - Maximum Aggregate Size
- Workability
- Material Specifications
Concrete mixtures for paving should be designed to produce the required **flexural strength**, provide adequate **durability**, and have appropriate **workability** considering the placement and finishing equipment to be used.”
Vehicle loads impart
  - Compressive stress in the upper ½ of the slab
  - Tensile stress in the lower ½ of the slab
Concrete is weaker in tension than compression so the tensile strength controls the pavement design
ACI 330 provides pavement design thicknesses for flexural strengths from 500 to 550 psi
Flexural / Compressive Strength

- Flexural strength, or Modulus of Rupture, is calculated from correlations to compressive strength:
  - For rounded (gravel) mixes:
    \[
    \text{MOR (psi)} = 8 \sqrt[3]{f_c'} \quad \text{(in.-lb units)}
    \]
  - For Angular (ledge rock) mixes:
    \[
    \text{MOR (psi)} = 10 \sqrt[3]{f_c'} \quad \text{(in.-lb units)}
    \]
### TABLE 4.2.1—EXPOSURE CATEGORIES AND CLASSES (Definitions)

<table>
<thead>
<tr>
<th>Category</th>
<th>Severity</th>
<th>Class</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>F</strong></td>
<td>Not applicable</td>
<td>F0</td>
<td>Concrete not exposed to freezing and thawing cycles</td>
</tr>
<tr>
<td></td>
<td>Moderate</td>
<td>F1</td>
<td>Concrete exposed to freezing and thawing cycles and occasional exposure to moisture</td>
</tr>
<tr>
<td></td>
<td>Severe</td>
<td>F2</td>
<td>Concrete exposed to freezing and thawing cycles and in continuous contact with moisture</td>
</tr>
<tr>
<td></td>
<td>Very Severe</td>
<td>F3</td>
<td>Concrete exposed to freezing and thawing cycles and in continuous contact with moisture and exposed to deicing chemicals.</td>
</tr>
<tr>
<td><strong>S</strong></td>
<td>Not applicable</td>
<td>S0</td>
<td>Water-soluble sulfate (SO$_4$)$_2$ in soil, percent by weight</td>
</tr>
<tr>
<td></td>
<td>Moderate</td>
<td>S1</td>
<td>SO$_4$ $&lt;$ 0.10</td>
</tr>
<tr>
<td></td>
<td>Severe</td>
<td>S2</td>
<td>0.10 $\leq$ SO$_4$ $&lt;$ 0.20</td>
</tr>
<tr>
<td></td>
<td>Very Severe</td>
<td>S3</td>
<td>SO$_4$ $&gt;$ 2.00</td>
</tr>
<tr>
<td><strong>P</strong></td>
<td>Not applicable</td>
<td>P0</td>
<td>Dissolved Sulfate (SO$_4$)$_2$ in water, ppm</td>
</tr>
<tr>
<td></td>
<td>Required</td>
<td>P1</td>
<td>SO$_4$ $&lt;$ 150</td>
</tr>
<tr>
<td><strong>C</strong></td>
<td>Not applicable</td>
<td>C0</td>
<td>In contact with water where low permeability is not required</td>
</tr>
<tr>
<td></td>
<td>Moderate</td>
<td>C1</td>
<td>In contact with water where low permeability is required</td>
</tr>
<tr>
<td></td>
<td>Severe</td>
<td>C2</td>
<td>Concrete exposed to moisture and an external source of chlorides</td>
</tr>
</tbody>
</table>
## Table 4.1—Recommended air contents

<table>
<thead>
<tr>
<th>Nominal maximum size aggregate, in. (mm)</th>
<th>Typical air contents of non-air-entrained concrete, %</th>
<th>Recommended average air content for air-entrained concretes, %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mild exposure</td>
</tr>
<tr>
<td>3/8 (10)</td>
<td>3.0</td>
<td>4.5</td>
</tr>
<tr>
<td>1/2 (13)</td>
<td>2.5</td>
<td>4.0</td>
</tr>
<tr>
<td>3/4 (19)</td>
<td>2.0</td>
<td>3.5</td>
</tr>
<tr>
<td>1 (25)</td>
<td>1.5</td>
<td>3.0</td>
</tr>
<tr>
<td>1-1/2 (38)</td>
<td>1.0</td>
<td>2.5</td>
</tr>
</tbody>
</table>

Note: Tolerances: ±1.5%. There is conflicting opinion on whether air contents lower than those given in the table should be permitted for high-strength (over 5500 psi [38 MPa]) concrete. This committee believes that where supporting experience or experimental data exist for particular combinations of material, construction practices, and exposure, the air contents can be reduced by approximately 1%.
Mix Design Requirements

- 4,500 psi
  - Not for the strength, for the durability
- 5.5 or 6.0% Air, +/- 1.5%
  - For maximum aggregate size of 1.5 or 1.0”
- Max w/c ratio of 0.45
- What about slump?
  - With water reducing admixtures higher slumps attainable with low w/c ratio
  - NYSDOT will use slump to “monitor” consistency, not as an accept or reject test.
Overview of the Document:

- Pavement Design – CH 3
- Materials – CH 4
- Construction – CH 5
- Inspection and Testing – CH 6
- Maintenance and Repairs – CH 7
Construction

- ACI Certified Finishers
- Paving Equipment
- Placing, Finishing and Texturing
- Hot / Cold weather placements
- Jointing
- Parking Lot Geometry
ACI Certified Finishers

- Flatwork Finisher Certification
  - Placement planning, pre-construction meetings
  - Concrete materials, mix designs, and testing
  - Site prep
  - Flatness and Levelness specifications and testing
  - Placing and Finishing
  - Curing & Jointing
  - Hot & Cold weather placements

- Also a great idea for the inspector / engineer...
Placing, Finishing and Texturing

- Broom or dragged finish
- Float finish
- What about trowelling?
  - Seals surface, overworks surface, removes air content from surface....
Placing, Finishing and Texturing

- What about a test panel?
  - Often not employed
    - Not necessary for non-decorative concrete
    - Contractor hates doing them as they lose a production day
- But....
  - Ensures the owner gets what they want
  - Ensures the contractor gets paid if satisfactory work performed.
Upstaters are great at cold weather concrete!!
- All have Insulated blankets
- Most have enclosed a placement to protect it
- Most have heated the ground to thaw and cure concrete
Hot / Cold weather placements

- We, unfortunately, are not as good at warm / hot weather placements

- Have you ever seen:
  - Sun shades erected on site?
  - Wind screens constructed to protect the slab from evaporation?
  - Spray nozzles constructed to mist / fog the air?
Overview of the Document:

- Pavement Design – CH 3
- Materials – CH 4
- Construction – CH 5
- Inspection and Testing – CH 6
- Maintenance and Repairs – CH 7
Inspection

- Starts with a good specification....

Provided with DAP
SECTION 32 13 13.50 – CONCRETE PAVEMENT FOR PARKING LOT APPLICATIONS

PART 1 - GENERAL .................................................................................................................................2
1.0 PROJECT IDENTIFICATION ..............................................................................................................2
1.1 RELATED DOCUMENTS ....................................................................................................................2
1.2 SUMMARY .......................................................................................................................................2
1.3 DEFINITIONS .................................................................................................................................2
1.4 REFERENCED STANDARDS AND MANUALS .....................................................................................4
1.5 SUBMITTALS ....................................................................................................................................6
1.6 QUALITY ASSURANCE ...................................................................................................................7
1.7 DELIVERY, STORAGE, AND HANDLING .......................................................................................8

PART 2 - PRODUCTS ............................................................................................................................8
2.1 CONCRETE MATERIALS ................................................................................................................8
2.2 STEEL REINFORCEMENT ..............................................................................................................9
2.3 ADMIXTURES ...............................................................................................................................9
2.4 FIBER REINFORCEMENT ..............................................................................................................9
2.5 CURING MATERIALS ....................................................................................................................10
2.6 JOINT AND SEALANT MATERIALS ...............................................................................................10
2.7 CONCRETE MIXTURES ................................................................................................................10

PART 3 - EXECUTION ........................................................................................................................11
3.1 SUBGRADE PREPARATION .........................................................................................................11
3.2 SUBBASE .....................................................................................................................................11
3.3 FORMWORK ..............................................................................................................................12
3.4 STEEL REINFORCEMENT ............................................................................................................12
3.5 CONCRETE PLACEMENT .............................................................................................................13
3.6 CONCRETE PROTECTION AND CURING ....................................................................................15
3.7 JOINTS ........................................................................................................................................16
3.8 JOINT FILLING ............................................................................................................................17
3.9 OPENING TO TRAFFIC ...............................................................................................................17
3.10 TOLERANCES .............................................................................................................................18
3.11 FIELD QUALITY ACCEPTANCE .................................................................................................18
3.12 MEASUREMENT AND PAYMENT .............................................................................................20
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5</td>
<td>SUBMITTALS</td>
<td>6</td>
</tr>
<tr>
<td>1.6</td>
<td>QUALITY ASSURANCE</td>
<td>7</td>
</tr>
<tr>
<td>1.7</td>
<td>DELIVERY, STORAGE, AND HANDLING</td>
<td>8</td>
</tr>
<tr>
<td><strong>PART 2 - PRODUCTS</strong></td>
<td></td>
<td><strong>8</strong></td>
</tr>
<tr>
<td>2.1</td>
<td>CONCRETE MATERIALS</td>
<td>8</td>
</tr>
<tr>
<td>2.2</td>
<td>STEEL REINFORCEMENT</td>
<td>9</td>
</tr>
<tr>
<td>2.3</td>
<td>ADMIXTURES</td>
<td>9</td>
</tr>
<tr>
<td>2.4</td>
<td>FIBER REINFORCEMENT</td>
<td>9</td>
</tr>
<tr>
<td>2.5</td>
<td>CURING MATERIALS</td>
<td>10</td>
</tr>
<tr>
<td>2.6</td>
<td>JOINT AND SEALANT MATERIALS</td>
<td>10</td>
</tr>
<tr>
<td>2.7</td>
<td>CONCRETE MIXTURES</td>
<td>10</td>
</tr>
<tr>
<td><strong>PART 3 - EXECUTION</strong></td>
<td></td>
<td><strong>11</strong></td>
</tr>
<tr>
<td>3.1</td>
<td>SUBGRADE PREPARATION</td>
<td>11</td>
</tr>
<tr>
<td>3.2</td>
<td>SUBBASE</td>
<td>11</td>
</tr>
<tr>
<td>3.3</td>
<td>FORMWORK</td>
<td>12</td>
</tr>
<tr>
<td>3.4</td>
<td>STEEL REINFORCEMENT</td>
<td>12</td>
</tr>
<tr>
<td>3.5</td>
<td>CONCRETE PLACEMENT</td>
<td>13</td>
</tr>
<tr>
<td>3.6</td>
<td>CONCRETE PROTECTION AND CURING</td>
<td>15</td>
</tr>
<tr>
<td>3.7</td>
<td>JOINTS</td>
<td>16</td>
</tr>
<tr>
<td>3.8</td>
<td>JOINT FILLING</td>
<td>17</td>
</tr>
<tr>
<td>3.9</td>
<td>OPENING TO TRAFFIC</td>
<td>17</td>
</tr>
<tr>
<td>3.10</td>
<td>TOLERANCES</td>
<td>18</td>
</tr>
<tr>
<td>3.11</td>
<td>FIELD QUALITY ACCEPTANCE</td>
<td>18</td>
</tr>
<tr>
<td>3.12</td>
<td>MEASUREMENT AND PAYMENT</td>
<td>20</td>
</tr>
</tbody>
</table>
Inspection and Testing

- Subgrade/Subbase
- ACI certified inspectors
  - Plastic Properties
- Compressive/Flexural Strength
- Construction verification by owners representative
  - We now offer the ACI Transportation Inspector Certification
Overview of the Document:

- Pavement Design – CH 3
- Materials – CH 4
- Construction – CH 5
- Inspection and Testing – CH 6
- *Maintenance and Repairs – CH 7*
Maintenance and Repairs

- Sealing and joint maintenance
- Full Depth Repair
- Under sealing and Leveling
- Overlays – Over Asphalt and Existing Concrete
- Cleaning
Always Specify Concrete

- Cost Savings
- Pricing of concrete is more competitive than ever.
- Reference to ACI 330 R-08 is an insurance policy – covers all aspects of concrete parking lots.
DAP
(Design Assistance Program)

- Program for specifiers
- CAD drawings, joint layout, pavement thickness
Questions

1. What is the best design methodology for concrete parking lot design?
   - A. AASHTO design
   - B. 8” of concrete over 10” of structural sub-base
   - C. ACI 330
   - D. All of the above
Questions

1. What is the best design methodology for concrete parking lot design?

   C. ACI 330
Questions

3. What is the best practice regarding secondary reinforcement?

- A. Welded wire mesh should be placed at or above mid slab depth.
- B. WWM works best when rusty or has oily coatings.
- C. WWM should be placed in the lower 1/3 of the pavement to increase tensile strength where it matters.
- D. None of the above
Questions

3. What is the best practice regarding secondary reinforcement?

A. Welded wire mesh should be placed at or above mid slab depth.
Questions

4. What is not a recommendation for control joint construction:

• A. Maximum joint spacing 27’ in any direction
• B. Cuts should be ¼ of the slab thickness
• C. Joints should be cut before drying shrinkage cracks appear
• D. Concrete cracks in predictable locations; control joint cuts cut in these locations will result in a happier owner.
Questions

4. What is not a recommendation for control joint construction:

   A. Maximum joint spacing 27’ in any direction
Questions

5. What outputs are *not* provided by NRMCA’s Design Assistance Program (DAP)
   - A. Structural design
   - B. Project specification developed for project
   - C. Foundation design for the building
   - D. Joint layout pattern
Questions

5. What outputs are **not** provided by NRMCA’s Design Assistance Program (DAP)

- C. Foundation design for the building
Thank you!

Greg Novitzki, P.E.
NYMATERIALS
gnovitzki@nyconcrete.com