Design and Construction of Concrete Parking Areas

Session W59, CONEXPO – CON/AGG 2014
Wednesday, March 5, 2013, 1:00 – 2:30 pm

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Concrete vs. asphalt considerations

• Upkeep & maintenance
• Aesthetics
• Lighting & safety
• Construction scheduling
• Site soils, environmental considerations
• Economics of alternate designs
  – Construction costs
  – “Life cycle” costs

Pavement selection trends, economics

• Concrete is no longer more expensive to construct
• Life cycle considerations further enhance this value for the owner
• Other facility costs and operating expenses can be reduced when pavements are concrete
• Sustainability and environmental concerns favor concrete
Pavement economics have changed!

Topics for discussion

- Pavement Design
- Jointing & Reinforcement
- Planning & Construction
- What goes wrong & how can it be avoided?

Design resources & considerations

- Design loads are truck numbers and frequencies
- Required input:
  - Strength of subgrade / subbase
  - Concrete strength
  - Traffic (truck loads and frequencies)
  - Design life
- Preferred references:
  - ACI 330 documents
  - ACPA documents
- Caution is advised:
  - AASHTO documents – oriented toward highway pavements, not generally appropriate
  - Don’t address most details and options for parking lots

Not recommended!
ACI committee 330 documents

330R-01, Guide for Design and Construction of Concrete Parking Lots
330.1-03, Specification for Unreinforced Concrete Parking Lots
Under development:
330.X, Guide for Design and Construction of Concrete Site Paving for Heavy Industrial and Trucking Facilities

General Scope of 330R:
Traffic, 0 to 700 trucks/day
Pavement thickness, 4” to 9”
Load transfer requirements, moderate

Definition – load transfer

- Shear strength provided at joints (or cracks) by dowels or other features, aggregate interlock, or contact friction
- Significantly reduces load-related deflection

Without load transfer:
Excessive deflections and flexure, performs like free edge loading

With load transfer:
Deflections and flexural stresses are reduced
Concrete pavement design

- Thickness determination, based on:
  - Design life
  - Traffic loads & frequencies
  - Subgrade (or subbase) support capacity
  - Concrete strength

- Jointing / reinforcement
  - Load transfer considerations
  - Prevention of uncontrolled crack issues

- Other design questions
  - Grades & drainage
  - Edge effects
  - Panel sliding

**ACI 330R-08 thickness table (Table 3.4)**

<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>
**Estimating \( k \) value**

**Additional guidance:**
ACI 330R-08, Appendix B

Table B.1 - Soil characteristics pertinent to parking lot pavements

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**Is a subbase layer needed?**

- "Subbase" is a layer of imported or improved material between the natural site material (subgrade) and the concrete
- Can result in higher \( k \) value for design and slightly thinner section
  - Probably can’t be justified on this basis
- May warrant consideration if:
  - Construction platform is needed
  - Subgrade is very poor quality
  - Heavy truck traffic & load transfer concerns
  - Pumping of subgrade is likely
- If used, \( k \) value for design can be adjusted

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**Concrete strength – MOR vs. \( f'c \)**

- Compressive strength \((f'c)\) recommended for acceptance & QC
- Modulus of rupture (MOR, as per ASTM C78) used in design
- Relationship can be documented for any mix via lab testing or can be estimated:
  
  \[
  \text{MOR (psi)} = 8\sqrt{f'(\text{in.-lb units})} \quad (3-1)
  \]
  
  \[
  \text{MOR (psig)} = 10\sqrt{f'(\text{in.-lb units})} \quad (3-2)
  \]
- Use Eq. 3-1 with smooth, rounded aggregates or when no data exists (4000 psi \( f'c \approx 505 \) psi MOR)
- Use Eq. 3-2 when materials data supports higher MOR’s – usually with crushed, angular aggregates (4000 psi \( f'c \approx 630 \) psi MOR)
### Traffic categories used in the thickness table

**Table 3.3—Traffic categories**

<table>
<thead>
<tr>
<th>Category</th>
<th>Single units (no truck)</th>
<th>Multiple units (semi-trailer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>166.93</td>
<td>51.03</td>
</tr>
<tr>
<td>B</td>
<td>98.30</td>
<td>30.76</td>
</tr>
<tr>
<td>C</td>
<td>47.01</td>
<td>23.88</td>
</tr>
<tr>
<td>D</td>
<td>24.40</td>
<td>16.61</td>
</tr>
</tbody>
</table>

**Axles per 1000 trucks**

<table>
<thead>
<tr>
<th>Axle load, kips</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category A</td>
<td>166.93</td>
<td>98.30</td>
<td>47.01</td>
<td>24.40</td>
<td>12.00</td>
</tr>
<tr>
<td>Category B</td>
<td>51.03</td>
<td>30.76</td>
<td>23.88</td>
<td>16.61</td>
<td>8.30</td>
</tr>
<tr>
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<td>51.03</td>
<td>30.76</td>
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<td>51.03</td>
<td>30.76</td>
<td>23.88</td>
<td>16.61</td>
<td>8.30</td>
</tr>
</tbody>
</table>

### Using the thickness table

**Using the thickness table**

<table>
<thead>
<tr>
<th>MOR, psi</th>
<th>2000 cycles (EIR = 18.8, R = 60)</th>
<th>5000 cycles (EIR = 9.8, R = 80)</th>
<th>10,000 cycles (EIR = 4.8, R = 87)</th>
</tr>
</thead>
<tbody>
<tr>
<td>400</td>
<td>450</td>
<td>490</td>
<td>530</td>
</tr>
<tr>
<td>500</td>
<td>500</td>
<td>550</td>
<td>600</td>
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<tr>
<td>600</td>
<td>600</td>
<td>650</td>
<td>700</td>
</tr>
<tr>
<td>700</td>
<td>700</td>
<td>750</td>
<td>800</td>
</tr>
</tbody>
</table>

**Axle-load distributions used for preparing Tables 3.3 and 3.4**

ACI 355R-08

Appendix A, Table A.1
Keeping thickness in perspective…

So what’s really important here?

• “Rules of thumb” work fine for many small projects.
• Actual overload failures due to insufficient thickness are rare.
• Most thickness design is conservative for assumed loads.
• More critical issues:
  – Is heavier traffic channelized?
  – Subgrade / subbase uniformity
  – Drainage & maintenance

Other design considerations

• Interior vs. edge loadings:
  – Thickness table assumes interior loadings with moderate load transfer at joints
  – Pavement edges or isolation joint sections may need thickening (or integral curbs) if they will receive wheel loads
  – Thick sections abutting flexible pavement (asphalt)
• Load transfer conditions:
  – Higher levels of load transfer recommended for heavier design loads and higher truck volumes
• In-plane (sliding) forces:
  – Special details suggested in areas of high vehicle turning or braking forces to prevent panel sliding

Jointing and Reinforcement
Joint design and layout affects performance

Typical concrete volume changes

Drying shrinkage and cracking

Shrinkage + Restraint = Cracking

Cracking results from combined effects of restraint and shrinkage (drying and/or thermal)... …whenever resulting tensile stresses exceed tensile strength.
**Differential shrinkage, warping / curling of slabs**

- Can result from differential moisture created by surface drying while the slab bottom remains wet
- Can also result from differential temperature
- Can cause loss of support near panel edges, movement and faulting at joints, mid-panel cracking

**Objectives of jointing**

- Control the location, width, and appearance of expected cracks
- Facilitate construction
- Accommodate normal slab movements
- Provide load transfer where needed
- Minimize performance implications of any random (unexpected) cracks

**Spacing of joints based on cracking tendency**

The extent of cracking due to key influences is somewhat predictable; joints can be spaced accordingly.

**RECOMMENDED SPACING of JOINTS FOR CRACK CONTROL**

<table>
<thead>
<tr>
<th>THICKNESS IN</th>
<th>SPACING FT</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>8-10</td>
</tr>
<tr>
<td>5</td>
<td>10-12</td>
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<tr>
<td>6</td>
<td>12-15</td>
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<tr>
<td>7</td>
<td>14-15</td>
</tr>
<tr>
<td>8+</td>
<td>15</td>
</tr>
</tbody>
</table>

Exception: good design may call for even closer joint spacings due to load transfer considerations.
Types of joints in concrete pavement

- Control joint
- Construction joint
- Isolation joint

Load transfer joint details

- Aggregate Interlock
- Keyways
- Dowels
- TIEBARS ≠ DOWELS!
  (not used for load transfer)

Round dowels – generally for 8”+ thickness
When used, the purpose of secondary steel reinforcement is to keep cracks from opening. To do this, it must be located above the mid-thickness.

Steel reinforcement

It is almost impossible to place rolled wire mesh in the upper thickness where it can function. Rebar on chairs or welded rigid mats perform better if steel is called for.

Secondary steel reinforcement is often misunderstood and can rarely be justified in flatwork that is properly jointed.

*If steel is used, it should generally be cut at all joints!*
Unreinforced concrete pavement

Today, unreinforced concrete is the most common design for the majority of concrete pavements. Even heavy traffic highways are built without steel reinforcement.

Control joint options

Control joints can be made by tooling a groove or pushing an insert into plastic concrete, or by sawing a slot in hardened concrete. The depth of the void must be at least 1/4 of the slab thickness to weaken the section enough to make it crack.

Tooled control joints

Advantages:
- Simplest to make
- Most reliable crack initiation

Disadvantages:
- Most noticeable joint
- Not smoothest for rolling wheels
- Not designed for sealers / fillers
Saw-cut control joints

**Advantages:**
- Makes best sealant reservoir
- Not as noticeable
- Smooth ride

**Disadvantages:**
- Timing critical to success
- Least reliable crack initiation with gravel aggregates
- More expensive to make

Timing of joint sawing – a critical factor

Saw-cut joints must be made within 4-12 hours after final finishing.

This joint was sawed soon enough

This one was sawed too late

Early entry “dry cut” saws

- Designed to initiate cracks with a shallow cut made much earlier than with wet-cut saws
- Timing - the “window of opportunity” is 1 to 2 hours if shallow cuts are used
- Also used to cut 1/4 or 1/3 in normal timing windows
Use of construction joints

Construction joints are used between separate concrete placements, typically along placement lane edges. They may use keyways or other features designed for load transfer.

Butt joints are recommended for most parking lots where load transfer needs are minimal.

Keyways are now only recommended for entrance drive / street longitudinal construction joints ≥ 10" thick and should be tied.

Keyways as detailed in earlier documents

1/4 Slope

0.2D

0.1D

Trapezoidal

Half-round

This detail is no longer included in ACI 330R or any ACPA references!

Typical keyway joint performance issues
Isolation joints

...are sometimes called expansion joints but should generally not be used to provide for expansion. They provide no load transfer and should not be used as regularly spaced joints in a joint layout. Their proper use is to isolate fixed objects, providing for slight differential settlement without damaging the pavement.

Improper use of isolation joints

- If isolation joints are used as routine joints:
  - Slabs “crawl” as isolation joints compress
  - Adjacent control joints open and fill with debris
  - No load transfer
  - Failure of sealants
  - Water intrusion

- Common issue in construction practice

Common details for isolation of fixtures

Square

- Inlet

Diagonal

- Inlet

Circular

- Inlet

Square with Fillets

- Inlet

None

- Inlet

Telescoping Manhole

- Inlet
In many cases, control joints and construction joints may be used interchangeably, depending on the preferred direction of paving lanes.

- Load transfer requirements must be considered.
- Isolation joints should be avoided in traffic areas except where differential movement or settlement must be accommodated (use thickened edges).

**Joint layout guidelines**

- **Things to Do**
  - Match existing joints or cracks
  - Cut at the proper time
  - Place joints to meet in-pavement structures
  - Adjust spacings to avoid small panels or angles
  - Intersect curves radially, edges perpendicular
  - Keep panels square

- **Things to Avoid**
  - Slabs < 1 ft. wide
  - Slabs > 15 ft. wide
  - Angles < 60° (90° is best)
  - Creating interior corners
  - Odd Shapes (keep slabs square)
  - Offset (staggered) joints
  - Isolation (unthickened) joints in traffic areas
Jointing layout – dealing with corners, acute angles, edges with extreme curvature

Sealing of joints
• Topic of some debate
• Sealants must be maintained and drainage design must be effective
• Low cost poured sealants not durable
• Some joint types difficult to seal
• Factors to consider in whether or not to seal joints:
  – Traffic level
  – Soil types & local performance
  – Subbase use
  – Presence of wind blown debris

Concrete Materials
Concrete materials – what to specify / order

- **Strength**
  - Consistent with design
  - More is not necessarily better

- **Durability**
  - Entrained air for freeze/thaw
  - Sulfates, AAR considerations if applicable

- **Other performance requirements**
  - Economy
  - Workability
  - Lowest shrinkage potential
    - Water content, slump
    - Aggregate size & grading

Freeze-thaw severity zones

- **Entrained air**
  - Used to provide freeze-thaw durability
  - Requires extra QC attention, testing

Supplemental cementitious materials – “SCMs”

- **Pozzolanic benefits**
  - Lower heat of hydration, reduced slump loss
  - Consumption of COH, less efflorescence
  - Higher ultimate strengths
  - Greater overall cementitious efficiency

- **Improved concrete rheology and paste density**
  - Lower water demand
  - Improved pumping & finishing
  - Reduced porosity & improved pore character
  - Improved consolidation & formed finishes

- **Other chemistry interactions, durability benefits**
  - Lower permeability
  - Sulfate resistance
  - Mitigation of aggregate reactivity

- **Environmental benefits**
  - Recycled materials – LEED, etc.
  - Reduced consumed energy to produce
  - Lower related CO₂ emissions
  - Enhanced reflectivity with GGBFS
Construction best practices, options

Pre-construction conference

- Indispensable in avoiding problems and making the project go smoothly
- Should cover all functions and responsibilities
- Improves project quality
- Saves time and money

Subgrade preparation

- Compact with proper moisture content
- Check density with testing or proof rolling
- Fine grading
- Remove and replace soft or unsuitable soils
- Consider subgrade stabilization when extremely poor soils are encountered
- Insure adequate surface drainage
- Water table depth - well below subgrade
- Uniformity is the key!
Drainage and subgrade issues: #1 cause of failures

Compaction and moisture-density relationship

Compact granular materials near optimum moisture, plastic soils slightly above optimum.

Monitoring density

- Major projects – use a qualified testing firm
- Small projects & quick checks – proof rolling
  - Use if testing is unavailable or impractical, or to supplement testing
  - Use a loaded truck
  - Establish and enforce a criteria
  - Can help to locate soft spots, stump holes
**Grading tolerances for the subgrade / subbase**

- Deviations contribute to variations in concrete thickness and influence drag restraint & cracking
- Suggested tolerances: within + ¼", - ½" of design grade
- Tight tolerances are more critical for thin slabs

**Forming & placement sequencing**

Of the different sequencing options used, the method of paving in alternate lanes (lower photo) has been found most efficient and also helps minimize the adverse effects of shrinkage.

**Alternate lane slip-formed placement**
Should the subgrade be dampened prior to concrete placement?

- No longer recommended
- Drier subgrades help to equalize concrete moisture loss, minimizing slab curling
- ACI 330R-08: “normally dry” subgrade
- Consider circumstances

Concrete placement & finishing precautions

- Good strikeoff / screeding critical for surface tolerances
- Select slump based on paving equipment
- Avoid too much vibration in one place
- Limit use of bull float: straight-edging is preferred where vehicle speed > 5 mph
- Avoid: troweling, use of jitterbugs, any finishing steps while bleedwater is rising
- Jointing - saw within critical time window; make cuts / grooves at least 1/4 of thickness
- Texturing - use plenty!
- Curing - timing and effectiveness are critical

Simple strikeoff equipment
Basic vibrating screeds

More sophisticated placement equipment

Construction of “roll-over” integral curbs
Bull floats vs. straight edges

Residential finishing methods – not for paving!

No power trowels!
**Thickened edges**

Concrete at pavement edges or along isolation joints that will support wheel loads should be thickened to provide extra support.

**Example – thickened edge**

**Providing surface texture**
Avoiding excessive cracking influences

- Monitor evaporation rate & take appropriate steps when extreme
- Effective curing
- Repair subgrade ruts, minimize other subgrade drag influences
- Effective curing
- Extra precautions in cool weather or with slow strength-gain mixes: apply curing sooner and longer...
- Adequate strength before opening to traffic
- Effective curing

Curing effects on performance

- Reduces cracking
  - Delay of drying shrinkage
  - Minimizes warping
- Improves durability and lowers permeability
- Facilitates most rapid strength gain

Curing compound – most common method

- Spray membrane curing compound - ASTM C 309, white pigmented preferred
- Timing is critical - spray immediately after finishing
- Suggested application rate:
  - Maximum coverage: 200 ft² / gal
  - Higher rate (less coverage) for windy or dry conditions
**Opening to traffic**

- Rules of thumb:
  - Automobile traffic in 3 days
  - Truck traffic in 7 days
- Opening can be earlier if adequate strength has developed (2500+ psi)
- Fast track techniques can be used to open to traffic in just a few hours

**Other information contained in ACI 330R**

- Inspection and testing
- Maintenance and repair
- Suggested joint details
- Concrete overlays
  - Over existing concrete
  - Over asphalt
- Parking lot geometrics
Parking lot geometrics

<table>
<thead>
<tr>
<th>Angle</th>
<th>Small cars</th>
<th>Large cars</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Interlock</td>
<td>Overhang</td>
</tr>
<tr>
<td></td>
<td>Reduction</td>
<td>Vehicle</td>
</tr>
<tr>
<td></td>
<td>Aisle width</td>
<td>Module widths</td>
</tr>
<tr>
<td>45 deg</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 ft, 0 in.</td>
<td>2 ft, 4 in.</td>
</tr>
<tr>
<td></td>
<td>1 ft, 5 in.</td>
<td>2 ft, 1 in.</td>
</tr>
<tr>
<td></td>
<td>15 ft, 3 in.</td>
<td>18 ft, 0 in.</td>
</tr>
<tr>
<td></td>
<td>11 ft, 6 in.</td>
<td>13 ft, 0 in.</td>
</tr>
<tr>
<td></td>
<td>26 ft, 9 in.</td>
<td>31 ft, 0 in.</td>
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<tr>
<td></td>
<td>42 ft, 0 in.</td>
<td>49 ft, 0 in.</td>
</tr>
<tr>
<td>50 deg</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>1 ft, 10 in.</td>
<td>2 ft, 1 in.</td>
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<tr>
<td></td>
<td>1 ft, 6 in.</td>
<td>2 ft, 4 in.</td>
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<tr>
<td></td>
<td>15 ft, 9 in.</td>
<td>18 ft, 8 in.</td>
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<tr>
<td></td>
<td>12 ft, 0 in.</td>
<td>13 ft, 8 in.</td>
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<tr>
<td></td>
<td>27 ft, 9 in.</td>
<td>32 ft, 4 in.</td>
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<tr>
<td></td>
<td>43 ft, 6 in.</td>
<td>51 ft, 0 in.</td>
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<tr>
<td>55 deg</td>
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<tr>
<td></td>
<td>1 ft, 8 in.</td>
<td>1 ft, 8 in.</td>
</tr>
<tr>
<td></td>
<td>1 ft, 8 in.</td>
<td>2 ft, 5 in.</td>
</tr>
<tr>
<td></td>
<td>16 ft, 1 in.</td>
<td>19 ft, 2 in.</td>
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<tr>
<td></td>
<td>14 ft, 0 in.</td>
<td>14 ft, 8 in.</td>
</tr>
<tr>
<td></td>
<td>28 ft, 11 in.</td>
<td>33 ft, 10 in.</td>
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<tr>
<td></td>
<td>45 ft, 0 in.</td>
<td>53 ft, 0 in.</td>
</tr>
<tr>
<td>60 deg</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 ft, 5 in.</td>
<td>1 ft, 9 in.</td>
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<tr>
<td></td>
<td>1 ft, 9 in.</td>
<td>2 ft, 7 in.</td>
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<tr>
<td></td>
<td>16 ft, 4 in.</td>
<td>19 ft, 6 in.</td>
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<tr>
<td></td>
<td>13 ft, 4 in.</td>
<td>16 ft, 0 in.</td>
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<tr>
<td></td>
<td>29 ft, 8 in.</td>
<td>35 ft, 6 in.</td>
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<tr>
<td></td>
<td>46 ft, 0 in.</td>
<td>55 ft, 0 in.</td>
</tr>
<tr>
<td>65 deg</td>
<td></td>
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<tr>
<td></td>
<td>1 ft, 2 in.</td>
<td>1 ft, 10 in.</td>
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<tr>
<td></td>
<td>1 ft, 10 in.</td>
<td>2 ft, 9 in.</td>
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<tr>
<td></td>
<td>16 ft, 6 in.</td>
<td>19 ft, 9 in.</td>
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<tr>
<td></td>
<td>14 ft, 0 in.</td>
<td>17 ft, 0 in.</td>
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<tr>
<td></td>
<td>30 ft, 6 in.</td>
<td>36 ft, 9 in.</td>
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<td></td>
<td>51 ft, 0 in.</td>
<td>56 ft, 6 in.</td>
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<tr>
<td>70 deg</td>
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<td></td>
<td>1 ft, 0 in.</td>
<td>1 ft, 11 in.</td>
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<td></td>
<td>1 ft, 11 in.</td>
<td>2 ft, 10 in.</td>
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<tr>
<td></td>
<td>16 ft, 7 in.</td>
<td>19 ft, 10 in.</td>
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<tr>
<td></td>
<td>14 ft, 10 in.</td>
<td>18 ft, 4 in.</td>
</tr>
<tr>
<td></td>
<td>31 ft, 5 in.</td>
<td>38 ft, 2 in.</td>
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<tr>
<td></td>
<td>49 ft, 0 in.</td>
<td>58 ft, 0 in.</td>
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<tr>
<td>75 deg</td>
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<td></td>
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<tr>
<td></td>
<td>0 ft, 9 in.</td>
<td>1 ft, 11 in.</td>
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<tr>
<td></td>
<td>1 ft, 11 in.</td>
<td>2 ft, 11 in.</td>
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<tr>
<td></td>
<td>16 ft, 6 in.</td>
<td>19 ft, 9 in.</td>
</tr>
<tr>
<td></td>
<td>16 ft, 0 in.</td>
<td>20 ft, 0 in.</td>
</tr>
<tr>
<td></td>
<td>32 ft, 6 in.</td>
<td>39 ft, 9 in.</td>
</tr>
<tr>
<td></td>
<td>51 ft, 0 in.</td>
<td>59 ft, 6 in.</td>
</tr>
<tr>
<td>90 deg</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0 ft, 0 in.</td>
<td>2 ft, 0 in.</td>
</tr>
<tr>
<td></td>
<td>2 ft, 0 in.</td>
<td>15 ft, 6 in.</td>
</tr>
<tr>
<td></td>
<td>20 ft, 0 in.</td>
<td>43 ft, 4 in.</td>
</tr>
<tr>
<td></td>
<td>35 ft, 6 in.</td>
<td>51 ft, 0 in.</td>
</tr>
<tr>
<td></td>
<td>51 ft, 0 in.</td>
<td>56 ft, 0 in.</td>
</tr>
</tbody>
</table>

Summary – so what all is really important here?

- Subgrade support, subbase
- Proper thickness
- Jointing for crack control
- Load transfer design
- Pavement drainage design
- Materials & methods refined to minimize shrinkage and warping
- Special attention to curing
Questions?

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