Concrete Pavement Construction
CRCP Workshop
(A Guide for Quality Construction)
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Gerald D. Lankes
Texas Concrete Pavement Association
17 Steps to be Discussed

- Mix Design
- Rebar Placement
- Temperature Control
- Headers
- Work in front of the Spreader
- Paver Operations
- Mechanical Finishing
- Hand Finishing

- Depth Verification
- Timely Texture
- Timely Curing
- Timely Sawing
- Opening to Traffic
- Strength Testing
- Strength Problems
- Ride Quality
- Small/Irregular Placements
Mix Design

• 5 Sacks, up to maybe 5½ sacks, is all that is needed for most uses (470# to 517 #)
• Even more true with Optimized Gradation.
• With higher cement content comes:
  - increased heat of hydration
  - increased water demand
  - more shrinkage
Mix Design

• W/C
  - Of the total mix water added, about half is for Hydration; the rest is for Workability only.
  - The Workability Water is just sitting there as the Concrete reaches its Initial Set.
  - Results in interconnected voids, loss of strength and increasing permeability, a durability issue!
Mix Design

• Use Pozzolans and/or other SCM’s
• Benefits of Pozzolans and/or other SCM’s:
  - Mitigates adverse chemical reactions
  - Increases Ultimate Strength
  - Improves Workability and reduces permeability (reduces water demand)
  - Lowers Heat of Hydration
  - Economical!
Mix Design

• Use of Optimized Aggregate Gradation.
  - Eliminates gap grading in concrete.
  - Adds an intermediate aggregate
  - Will provide a denser concrete with more aggregate, less cement and less water!
Mix Design

• Maximizing the Coarse Aggregate will improve performance because................
  – Coarse Aggregate is stronger than paste.
  – Paste has all the freeze-thaw liability.
  – Paste has all the permeability liability.
  – Paste is the only component that shrinks.
Controlling Total Water

• You must Control the W/C Ratio
• You must control the Cementitious Content
• And you must control any onsite added water.
  - Onsite additions to concrete in a mixer truck must not exceed Mix Design W/C.
  - Can’t add water to dump trucks, but…
And then, there is this
Effect of Finishing Water

• Will raise the W/C ratio of the surface of the concrete!
• Higher W/C will reduce strength and durability.
• The surface is exactly where the most durability is needed because that is where the rubber meets the road.
Rebar Placement, CRCP
Longitudinal Rebar

- Holds cracks tightly together, so that load transfer is provided by aggregate interlock.
- Does contribute to load transfer
- 2003 CRCP Standards includes spacing tolerances. Contractor provides needed control.
- Concentrate on proper number of bars and general conformance to tolerances.
- Also, staggered splices.
Function of Transverse Rebar

• With timely sawing, controls longitudinal cracking.
• As a support for the longitudinal steel.
• Size (everything is a #6 bar with 2003 standard) and spacing is totally dependent on pavement thickness and width between free longitudinal Joints/Pav't edges.
• Spacing can change several times on an individual project!
Tie-bars, CRCP/CPCD

- Tie-bars provide transverse continuity of slab.
- Also provides continuity of rebar for CRCP.
- Multiple-piece tie-bars eliminate the problems associated with bending of single-piece tie-bars.
Tie-Bar Installation Requirements

- Multi-piece tie-bars require careful completion of threaded connection before the second pour.
- Single-piece tie-bars require pull-out tests to verify successful installation prior to second placement.
Temperature Control Methods

1. Using Pozzolans (“F” Fly Ash, Slag, etc.)
2. Paving at night/very early morning
3. Using Liquid Nitrogen
4. Cooling aggregate at Batch Plant
5. Chilled water
6. Using Ice
Important Items for Headers

• Careful, Deliberate Hand Vibration!
• There is a lot of hand finishing work.
• Careful transitions from previous placement or adjacent bridge.
• There are forms for the transverse joint and (usually) a short section of longitudinal forms.
Failure to properly hand vibrate the concrete at headers can lead to the following problems:
Concrete Placement

- Concrete can be delivered in either Transit Mix trucks or Dump Trucks.
- In either case, the concrete is placed as near as possible to its final location.
- Spreader augers or laborers with shovels are the only way to move the concrete (no rakes, vibrators, etc.)
• It is important to keep the base wet immediately in front of the paver, this helps keep the water you put in the concrete in the concrete.
Sampling concrete for testing with Dump Truck Delivery
Paver Operation
Slipform Paver

- Extrudes the Concrete Mix placed in front of the Spreader into the Pavement.
- Properly Consolidates the Concrete.
- Properly forms the Concrete at the proper Line and Grade.
- A somewhat technical but efficient and effective machine.
Remember Ride Quality Issues

You need to match batching rates with production rates in order to keep the paver moving at a constant speed, an important element to getting a good ride quality.
Mechanical Finishing
• The Mechanical Finisher completes the work of the Paver.
• Eliminates any small bump that might be present.
• Finds, but does not necessarily fix, any small low spot that might be present. (concrete may need to be added by hand)
• There are many types of Transverse Finish Machines.
Hand Finishing
• Most hand finishing is unnecessary and detrimental!

• Slipform Pavers do a very good job of providing a smooth riding surface.

• Excessive hand finishing negates the work of a good Paver, esp. if adding water.

• Hand finish what is needed, but only what is needed! (should be very minimal)

• After all, someone is getting ready to provide texture to the surface!
And then, there is this
Depth Verification
Importance

- Depth of Concrete Pavement is important to the pavement’s long-term life!
- Test can be performed from a work bridge or from other contractor’s equipment.
Timely Texture
• Micro-texture is needed to provide skid resistance to the surface.
• Tine texture is currently used as a means to remove water from the surface.
• To be effective, this needs to be done while the concrete is plastic enough to obtain the depth required.
• Mechanical methods are the norm for Tine Texture application, but hand applications can be used with smaller placements.
Insufficient Tine Texture
Timely Curing
• Proper curing is considered to be the one area needing the most improvement statewide!!!

• Water needed for hydration starts to evaporate from the surface as soon as it is placed.

• The surface is the area where proper hydration of the cement is needed the most!!!!!!!!

• Wind speed & relative humidity are the main factors that determine the rate of evaporation.
This chart is for “normal” concrete mixes with no Pozzolans. Using Concrete with Pozzolans will have different results.

From ACI & C-1 Manuals
## Environment vs. Evaporation

<table>
<thead>
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<th>Air Temp</th>
<th>R.H.</th>
<th>Conc Temp</th>
<th>Wind</th>
<th>Evap. Loss</th>
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<tr>
<td>75 F</td>
<td>50%</td>
<td>80 F</td>
<td>5 mph</td>
<td>0.10 (BL #1)</td>
</tr>
<tr>
<td>75 F</td>
<td>50%</td>
<td>80 F</td>
<td>20 mph</td>
<td>0.28 (280%)</td>
</tr>
<tr>
<td>75 F</td>
<td>20%</td>
<td>80 F</td>
<td>20 mph</td>
<td>0.40 (400%)</td>
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<tr>
<td>90 F</td>
<td>50%</td>
<td>95 F</td>
<td>5 mph</td>
<td>0.11 (110%)</td>
</tr>
<tr>
<td>75 F</td>
<td>80%</td>
<td>80 F</td>
<td>5 mph</td>
<td>0.06 (BL #2)</td>
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<tr>
<td>75 F</td>
<td>20%</td>
<td>80 F</td>
<td>25 mph</td>
<td>0.50 (833%)</td>
</tr>
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</table>
Environment vs. Evaporation

- The environmental factors that add the most to evaporation rates are:
  1. High Wind Speed and
  2. Low Relative Humidity
- Air and Concrete Temperature are minor environmental factors to evaporation rates.
Curing

- Provide independent curing equipment when required to meet requirements of Item 360.
- Prevent surface drying before application of the curing system.
- Immediately following carpet drag, if needed, apply an of evaporation retardant as per manufacturers recommendations.
Curing

- Provide metal-tine finish immediately after concrete has set enough for consistent tines.
- Do not allow the concrete surface to dry before applying the curing compound.
What is Wrong with this Picture?
Timely Sawing
Why Saw Timely?

- Freshly placed concrete develops stress faster than it develops strength.
- When stress exceeds strength, a stress relief crack occurs. Sawing needs to be complete before this happens.
- You need to be sawing just as soon as you can walk on the pavement and……
- Should saw with possible minor raveling of cut to increase your ability to avoid the uncontrolled cracking (Maximize window of opportunity).
Opening to Traffic
Construction Traffic, 2004 Specs

- Pavement must be 48 hours old.
- Pavement must have 450 psi strength.
- Maturity method can be used.
- Keep Delivery equipment 2’ from edge.
- Keep track of paver 1’ from edge.
- Repairs to curing and/or texture ASAP
All Traffic

- Pavement must be 7 days old and have 450 psi strength.
- Clean the pavement.
- Shoulder up the edges if needed.
- Seal Joints.
- Perform all safety related work.
Emergency Opening

- Written Permission is required.
- Pavement must be 72 hours old.
- Clean the pavement.
- Shoulder up the edges if needed.
- Perform all safety related work.
“Failing” Strength Tests

• Strength, for pavements, is not as important as:
  - Depth
  - Impermeability
  - Durability
  - Ride Quality
  - Rigid support underneath
Production Strength Problems
Low Production Strength Causes

(concrete design was previously ok, then problems developed)

1. High Entrained Air Content
2. High Water/Cement Ratio
3. Testing Problems
4. Dirty Aggregates
5. Batching Errors
6. Incompatibilities with Ingredients
7. Adding cement is not be the solution!!!
Requirements for Good Ride

- Consistent Concrete Mix
- Consistent Delivery of Sufficient Quantity
- Consistent Movement of Paver
- Paver needs Track line on which to operate
- Stringline supported at close enough intervals
- No excessive hand finishing
Formed Concrete Pavements

• Small Irregular Sections
  – Intersections
  – U-turns
  – Short variable width widening
  – Others

• A lot of what has been discussed is still pertinent.

• Differences do exist.
Differences Include

- Careful grading of forms is required.
- Wooden forms are common for curves.
- Small self-propelled screeds are common.
- Hand vibrate everything.
- Higher slump is needed due to handwork.
- Much more hand finishing is required.
- Hand Texturing & Hand Curing is common.
Typical Steel Form (defines ride)
Form Placement

- Clean and oil forms
- Forms must be within 2” of pavement depth.
- Provide stable support such that forms will support screed w/o deflection or movement.
- Secure forms to base.
- Pin every form section at ends and middle.
- Carefully grade form to ensure pavement has required ride quality (straightedge, eyeball, etc.)
Forming Curved Sections

• Use flexible, curved wood or metal forms for curves of 100 foot radius or less.
• Special attention must be made to the weight of screed used in these areas.
Form Removal

- Avoid damage while removing forms.
- Repair damaged & Honeycombed areas within 24 hours.
- If forms are removed before 72 hours after placement, cure the sides of Pav't.
Never ever give up!