10

Technical Summary

From chapter 10 (pages 275–290) of the *IMCP Manual* (reference information on page 16)

Troubleshooting

Table 10-1. Problems Observed Before the Concrete Has Set

Mixture and Placement Issues

1. Slump is Out of Specification

Potential Cause(s)	Actions to Consider/Avoid	See Page
Change in water content or aggregate grading	Check aggregate moisture contents and absorptions.	44, 47, 183, 206, 207, 211
	Check for segregation in the stockpile.	
	Make sure the batch water is adjusted for aggregate moisture content.	
	Conduct batch plant uniformity tests.	
	Check whether water was added at the site.	
Mix proportions	Check batch equipment for calibration.	207
Admixture dosage	Check delivery ticket for correct admixture dosage.	207
Concrete temperature too high or too low	Adjust the concrete placement temperature.	127
Haul time	Check the batch time on the concrete delivery ticket. Haul times should not be excessive.	209

2. Loss of Workability/Slump Loss/Early Stiffening

Potential Cause(s)	Actions to Consider/Avoid	See Page
Dry coarse aggregates	Make sure the aggregate stockpile is kept consistently at saturated surface-dry (SSD) (use soaker hoses if necessary).	206
Ambient temperature increases	Do not add water.	179, 182, 183, 206, 210, 226
	Chill the mix water or add ice.	
	Sprinkle the aggregate stockpiles.	
	Use a water reducer or retarder.	
	Do not increase the water/cement ratio to a value greater than the maximum approved mix design.	
	Use a mix design that includes slag or fly ash.	
Transport time too long	Reject the load if greater than specified.	183, 209
	Use retarder in the mixture.	
	Use an agitator rather than dump trucks.	
Mix proportions have changed	Check/monitor the moisture contents of the aggregate stockpiles.	206, 207, 246
	Check the batch weigh scales.	
	Verify that aggregate gradations are correct.	

(continued on the following page)

Mixture and Placement Issues, continued

2. Loss of Workability/Slump Loss/Early Stiffening, continued

Potential Cause(s)	Actions to Consider/Avoid	See Page
False setting (temporary)	Check for changes in cementitious materials.	58, 209, 211
	Reduce Class C fly ash replacement.	
	Change the type of water reducer.	
	Try restoring plasticity with additional mixing.	
	Contact the cement supplier.	
Incompatibility	Check for changes in the cementitious materials.	97, 246, 247
	Reduce Class C fly ash replacement.	
	Change chemical admixtures.	
	Change the batching sequence.	
	Cool the mixture.	
Variation in air content	Check the air content/air entrainer dosage.	56

3. Mixture is Sticky

Potential Cause(s)	Actions to Consider/Avoid	See Page
Sand too fine	Change the sand grading.	44, 109
Mix too sandy	Check the sand and combined aggregate grading.	180
Cementitious materials	Check the cementitious materials contents. (Mixtures containing GGBF slag and fly ash appear sticky but finish well and respond well to vibration energy.)	31, 109, 179, 214
	Lower the vibration energy to avoid segregation.	
	Adjust the mix proportioning.	
Using wood float on air-entrained concrete	Use magnesium or aluminum floats.	

4. Mixture Segregates

Potential Cause(s)	Actions to Consider/Avoid	See Page
Inconsistent concrete material—batching, mixing, placing	Check aggregate gradation; poorly graded mixtures may tend to segregate.	176, 206, 207, 208, 213, 215, 246
	Verify batching/mixing procedures so that the mixture is adequately mixed.	
	Check aggregate stockpile, storage, and loading procedures to prevent aggregate segregation.	
	Place concrete as close to final position as possible to minimize secondary handling.	
	Perform uniformity testing on batch plant, if necessary, use agitator trucks for transport.	
	Reduce the vibration energy if consolidation efforts cause segregation. (Vibration at 5,000–8,000 vpm is sufficient for most well-graded mixtures.)	

5. Excessive Fresh Concrete Temperature

Potential Cause(s)	Actions to Consider/Avoid	See Page
Hot ingredients	Do not add water.	128, 226, 247
	Follow hot-weather concreting practice as appropriate.	
	Chill the mix water or use ice.	
	Shade and sprinkle the aggregate stockpiles.	

(continued on the following page)

Mixture and Placement Issues, continued

5. Excessive Fresh Concrete Temperature, continued

Potential Cause(s)	Actions to Consider/Avoid	See Page
Long haul times	Adjust the hauling operation to minimize haul times.	209
	Adjust paving time to off-peak traffic time if hauling through public traffic.	
Hot weather	Follow hot-weather concreting practice as appropriate.	129, 226, 247
	Chill the mix water; sprinkle the aggregate stockpiles.	
	Pave at night or start paving in afternoon.	

6. Air Content is Too Low or Too High

Potential Cause(s)	Actions to Consider/Avoid	See Page
Temperature changes	The air-entraining admixture dosage may need to be adjusted during hot/cold weather.	186
Materials have changed	Check for uniformity of materials.	
Mix proportions have changed	Altering other admixture dosages may impact the effectiveness of the air-entraining admixture.	176, 180, 246
	Check slump; it is easier to entrain air with increasing concrete workability.	
	Check/monitor the moisture contents of the aggregate stockpiles.	
	Check the batch weigh scales.	
	Verify that aggregate gradations are correct.	
	Verify sand quantity.	
Short or inadequate mixing	Check the charging sequence.	209
	Increase mixing time.	
	Check if the blades of the mixer are missing or dirty.	

7. Variable Air Content/Spacing Factor

Potential Cause(s)	Actions to Consider/Avoid	See Page
Incorrect or incompatible admixture types	Change types or brands of admixtures.	186, 248
	Try to work within one manufacturer's family of admixtures if air-entraining agent is being combined with other admixtures.	
Admixture dosage	Check the batching equipment for calibration and settings.	207, 248
	Change the sequence of batching.	
Mix proportions have varied or changed	Check/monitor the moisture contents of the aggregate stockpiles.	176, 183, 206, 248
	Check the batch weigh scales.	
	Verify that aggregate gradations are correct.	
Cementitious materials	Check for changes in cementitious materials, particularly the loss-on-ignition (LOI) content of fly ash.	34
Poor plant configuration	Introduce aggregates together on the plant's belt feed (requires a multiple weigh hopper).	207
Poor aggregate grading	Use a more well-graded coarse and fine aggregate mixture.	176
	Check variation in the amount of materials retained on the #30 through #100 sieves.	
Temperature changes	Air-entraining admixture dosage may need to be adjusted during hot/cold weather.	56, 133, 247
	Altering other admixture dosages may impact the effectiveness of the air-entraining admixture; air-entraining admixtures work more efficiently with increasing workability.	
Variable mixing	Ensure that each batch is handled consistently in the plant.	207

Mixture and Placement Issues, continued

8. Mix Sets Early

Potential Cause(s)	Actions to Consider/Avoid	See Page
Cementitious materials	Check for changes in the cementitious materials; differing sources or changes in properties of a given material may result in incompatibility; changes in proportions may also affect setting times.	99
Admixture dosage	Check the dosage of chemical admixtures, particularly accelerators.	56, 99, 183, 207, 246
	Check the batching equipment.	
Hot weather	Adjust the mix proportions.	31, 99, 185, 186,
	Use mix designs that include GGBF slag or fly ash.	226, 246
	Use a retarder.	
	Reduce haul time if possible.	
	Reduce the placement temperature of the concrete.	
	In hot weather, use a hot weather mix design.	
	Cool the concrete ingredients.	

9. Delayed Set

Potential Cause(s)	Actions to Consider/Avoid	See Page
Excessive retarder dosage	Verify the proper batch proportions.	56, 183, 207, 246
	Check the batching equipment.	
	Reduce the dosage of the retarder.	
Excessive water reducer dosage	Verify the proper batch proportions.	56, 183, 207
	Reduce the dosage of the water reducer.	
Retarder not dispersed well	Improve mixing to disperse the retarder.	209
Supplementary cementitious materials interference	Reduce GGBF slag content; GGBF slag in excess of 25 percent can cause a dramatic increase in set time.	31
	Eliminate/reduce fly ash content in the mix.	
Cold placement temperature	Follow cold-weather concreting practices if appropriate.	228
Organic contamination	Verify the proper batch proportions.	39, 52, 207
	Check for contamination of water and aggregates.	

Mixture and Placement Issues, continued

10. Supplier Breakdown, Demand Change, Raw Material Changes

Potential Cause(s)	Actions to Consider/Avoid	See Page
Cement	Refer to backup lab mixes if conditions were anticipated.	28, 171, 211
	Switch sources, batch new mix designs, and develop new laboratory strength gain and maturity information. (This action may require a project delay. To avoid unacceptable delays, a contractual agreement should be arranged prior to paving, which allows for unforeseen material supply changes, burden of delay costs, and risk of paving during batch revision testing. If paving activity is continued during testing, compare early-age strengths (1- and 3-day) and maturity data to confirm that the new mix will perform adequately.)	
Supplementary cementitious materials	See cement supply change.	31
	Switch sources and compare early-age strengths (1- and 3-day) and maturity data to confirm that the mix will perform adequately.	
Aggregates	See cement supply change.	39
	Switch sources and compare early-age strengths (1- and 3-day) and maturity data to confirm that the mix will perform adequately.	
Chemical admixtures	See cement supply change.	55
	Switch admixture sources and compare early-age strengths (1- and 3-day) and maturity data to confirm that the mix will perform adequately.	

Edge and Surface Issues

11. Fiber Balls Appear in Mixture

Potential Cause(s)	Actions to Consider/Avoid	See Page
Fibers not thoroughly dispersed in mix	If added in bags, check the timing of addition and subsequent mixing.	62
	Some mixes do not break down bags as easily as others (i.e., smaller sized rounded coarse aggregate mixes); check compatibility.	
	Use a blower for synthetic fibers or a belt placer for steel fibers instead of bags.	

Edge and Surface Issues, continued

12. Concrete Surface Does Not Close Behind Paving Machine

Potential Cause(s)	Actions to Consider/Avoid	See Page
Insufficient volume contained in the grout box	Place more material in front of the paver; consider using a spreader.	209
The concrete is stiffening in the grout box	Check for premature concrete stiffening (admixture compatibility). (See no. 2: Loss of workability/slump loss/early stiffening.)	97
The fine/coarse aggregate volume or paste volume is too low	Check mixture proportions, particularly aggregate gradations.	171, 176
	Check the uniformity of aggregate materials/supplies.	
The finishing pan angle needs adjustment	Adjust the pan angle.	
The paver speed is too high or vibrators need to be adjusted	Slow the paver.	215, 248
	Lower the vibrator frequencies or use vibrators with greater force.	
	Adjust the location of the vibrators; raise them closer to the surface.	
	Place more material in front of the paver; consider using a spreader.	
	Change the vibrator angle.	

13. Concrete Tears Through Paving Machine

Potential Cause(s)	Actions to Consider/Avoid	See Page
Excessive concrete slump loss	Check for slump loss and mixture or weather changes.	109
	See no. 2: Loss of workability/slump loss/early stiffening.	
Insufficient concrete slump	Check the mixture proportions.	171
Angular fine aggregate (manufactured sand)	Replace a portion of the manufactured sand with natural sand.	39
Paver speed too high	Slow the paver.	
Coarse aggregate is segregated	Check the stockpile.	109, 206
Coarse aggregate is gap-graded	Check the combined aggregate grading.	109, 176
	Blend the aggregate with intermediate aggregates to achieve a uniform combined grading.	

14. Paving Leaves Vibrator Trails

Potential Cause(s)	Actions to Consider/Avoid	See Page
Vibrator frequency too low	Check if the seals on the vibrators are leaking.	248
Vibrator frequency too high	Lower the vibrator frequency.	248
Paver speed too slow	Increase the paver speed.	212
Non-workable concrete mix	Review concrete workability field test data.	109
	See no. 2: Loss of workability/slump loss/early stiffening.	
Over-sanded mixes	Increase the coarse aggregate.	176, 180
Poor combined aggregate grading	Check the combined aggregate grading.	176

Problems Observed Before the Concrete Has Set

Edge and Surface Issues, continued

15. Slab Edge Slump

Potential Cause(s)	Actions to Consider/Avoid	See Page
Poor and/or nonuniform concrete—gap-graded aggregate, high water/cement ratio, etc.	Verify the mix design and batching procedures.	176, 246
	Check the aggregate grading—use a well-graded combined aggregate gradation.	
Inadequate operation of equipment	Check the construction procedures.	212
	Adjust the outside vibrator frequency.	
	Adjust the side form batter.	
Improper equipment setup	Adjust the overbuild.	212
	Check the track speed (same on both sides).	
	Check the pan profile.	

16. Honeycombed Slab Surface or Edges

Potential Cause(s)	Actions to Consider/Avoid	See Page
Hot weather may induce premature stiffening	Follow hot-weather concreting practices if appropriate.	226
	See no. 2: Loss of workability/slump loss/early stiffening.	
Inadequate vibration	Check that all vibrators are working properly, at the right frequency and amplitude; the paver speed should not be too high.	248
	Add an additional vibrator near the slipformed edge.	
Poor workability	Check for changes in the aggregate grading.	176

17. Plastic Shrinkage Cracks (figures 5-30, 5-31, 10-1)

Potential Cause(s)	Actions to Consider/Avoid	See Page
High evaporation rate (excessive loss of moisture from surface of fresh concrete; i.e., evaporation rate > bleed rate)	Apply the curing compound as soon as possible to protect the concrete from loss of moisture.	158, 176, 191, 206, 224, 226
	Use additional curing measures: fogging, evaporation retarder, windbreaks, shading, plastic sheets, or wet coverings.	
	Make sure the absorptive aggregates are kept moist; a dry concrete mixture from concrete aggregates that are not saturated tends to surface dry at mixing. This is problematic if not accounted for.	
	Use a well-graded combined aggregate (gap gradation requires more paste and causes more shrinkage).	
	Refer to hot-weather concreting practices if appropriate.	
	Pave at night.	
	Chill the mixing water.	
	Dampen the subgrade.	
	Avoid paving on hot, windy days.	
	Consider adding fibers to the mix.	
Delayed setting time	Check the time of set.	114

Table 10-2. Problems Observed in the First Days After Placing

Strength

18. Strength Gain is Slow

Potential Cause(s)	Actions to Consider/Avoid	See Page
Cold temperature during/after placement	Heat the mix water.	31, 59, 121, 182,
	Use burlap/insulating blankets for protection from freezing.	224, 228, 233
	Use an accelerating admixture.	
	Eliminate/reduce GGBF slag and fly ash content in the mix.	
	Increase the cement content.	
	Use a Type III cement.	
	Utilize early-entry sawing to reduce the potential for random cracking.	
	Monitor the slab temperature with maturity sensors.	
Mix proportions or materials have changed	Check/monitor the moisture contents of the aggregate stockpiles.	176, 206, 207, 211
	Check for uniformity of the cementitious materials.	
	Check the batch weigh scales.	
	Verify that aggregate gradations are correct.	
	Verify that batch weights are consistent with the mix design.	

19. Strength is Too Low

Potential Cause(s)	Actions to Consider/Avoid	See Page
Cementitious materials	Check for changes in the cementitious materials.	211
	Check that the correct materials have been loaded into the cement/fly ash/slag silos.	
Water	Check the water content.	181, 206, 207
	Verify the aggregate moisture contents and batch weights.	
Change in sand grading	Check the sand stockpile to see whether the grading has changed.	176
Contamination with organics	Contamination of one of the ingredients with organics can also effect a sudden change in the required dosage of air-entraining admixture; try to isolate the source.	
Inadequate or variable mixing	Examine the mixer and mixing procedures.	207, 208
	Check for worn mixer blades.	
	Check for mixer overloading.	
	Batch smaller loads.	
	Check the sequencing of batching.	
	Check for mixing time consistency.	
	Conduct batch plant uniformity testing.	
Plant operations	Verify the acceptability of the batching and mixing process.	207, 208
	Check for adequate mixing times.	
	Check if water was added to the truck.	
Testing procedures	Verify proper making, curing, handling, and testing of strength specimens. (Flexural strength specimens are particularly vulnerable to poor handling and testing procedures.)	263
	Verify the machine acceptability testing.	
	Test the cores sampled from the pavement to verify acceptance.	
Air-void clustering	Use a vinsol resin-based air-entraining admixture.	100, 209
	Avoid retempering.	
	Increase the mixing time.	

Cracking

20. Early-Age Cracking (figures 5-32, 5-33, 5-34, 5-35, and 10-1)

Potential Cause(s)	Actions to Consider/Avoid	See Page
Concrete mixture	Check the combined aggregate grading.	31, 39, 55, 88, 97, 148,
	Examine the fine aggregates; fine aggregates may be too fine and angularity may cause harsh finishing (i.e., manufactured sands).	176, 228, 235
	Reduce the paste content (minimize shrinkage potential).	
	Materials incompatibility may lead to delayed set and/or higher concrete shrinkage; consider mixture component adjustments.	
	Eliminate or reduce the content of fly ash or GGBF slag in cool-weather conditions.	
	Consider using an accelerator in cold weather.	
Sawing	Saw as early as possible but avoid excessive raveling.	231, 233
	Saw in the direction of the wind.	
	Check that the diamond saw blade is appropriate for concrete aggregate hardness, fines, etc.	
	Use early-entry dry sawing.	
	Use HIPERPAV to model stress versus strength gain for conditions to determine the optimum sawing time.	
Curing	Improve/extend curing.	224
	Apply the curing compound at a higher rate.	
	Apply the curing compound sooner.	
	Use blankets between placing and saw-cutting.	
Insufficient joint depth	Check the saws for depth setting.	231, 233
	Check the saw blade for wear (carbide blades).	
	Check that saw operators are not pushing saws too fast, causing them to ride up.	
	Look for base bonding or mortar penetration into the open-graded base-altered effective section; increase the saw depth to create an effective weakened plane.	
	Check the slab thickness.	
Excessive joint spacing	Reduce spacing between the joints.	
	Slabs are too wide in relation to thickness and length; add intermediate joints.	
	Maintain a reasonable length-width ratio.	
Warping (slab curvature due to moisture gradient; the term "curling," however, is commonly used in the industry to cover both moisture- and temperature-related slab distortion)	Check the moisture state of base.	150, 224
	Improve or extend curing.	
	Minimize the shrinkage potential of the concrete mixture.	
	Cover the slab, particularly when night/day temperatures vary widely.	

(continued on the following page)

Cracking, continued

20. Early-Age Cracking, continued

Potential Cause(s)	Actions to Consider/Avoid	See Page
High temperature	Cool the raw materials before mixing the concrete: shade, spray, ice, liquid nitrogen	64, 156, 224, 226
	Cool the equipment.	
	Work at night.	
	Watch for shaded areas where drying and strength gain may vary within a single day's work.	
	Delay paving if conditions are too hot (>38°C [100°F]).	
	Apply an evaporative retardant prior to texturing.	
	Apply the curing compound at an additional dosage rate and consider a non-water-based compound with better membrane-forming solids.	
Too many lanes tied together (generally only a consideration for longitudinal direction)	Do not exceed 15 m (50 ft) of pavement tied together.	
	Add an untied construction or isolation joint.	
	To prevent additional cracking, consider sawing through a longitudinal joint to sever bars.	
Edge restraint (paving against an existing or previously placed lane)	Cracks occur due to restraint to movement (sometimes referred to as sympathy cracks).	
	Tool the joint or use an early-entry dry saw to form the joints as early as possible.	
	Match the joint location and type.	
	Eliminate tiebars in a longitudinal construction joint that is within 24 inches on either side of transverse joint locations. Match all locations of the joints in the existing pavement (cracks, too).	
Slab/base bonding or high frictional restraint	Moisten the base course prior to paving (reduce the base temperature by evaporative cooling).	191
	Use a bond-breaking medium (see reflective cracks).	
	If the base is open graded, use a choker stone to prevent the penetration of concrete into the base's surface voids.	
Misaligned dowel bars	Investigate whether the joints surrounding the crack have activated and are functioning; misaligned or bonded dowels may prevent joint functioning, causing cracks.	218
Cold front with or without rain shower	Use early-entry sawing to create a weakened plane prior to temperature contraction.	231, 233
	Skip-saw (saw every other joint or every third joint) until normal sawing can be resumed.	
	Use HIPERPAV to model stress versus strength-gain conditions that may warrant a suspension or change of paving activities.	

Joint Issues

21. Raveling Along Joints

Potential Cause(s)	Actions to Consider/Avoid	See Page
Sawing too soon	Wait longer to saw.	233
	Use formed joints.	
	Blank out transverse tining at transverse contraction joints.	
Saw equipment problem	Blade selection for the concrete (coarse aggregate type) may be inadequate.	233
	A bent arbor on the saw causes the blade to wobble.	
	The second saw cut can go back and forth; consider a single-cut design.	
Sawing too fast	Slow down.	233

22. Spalling Along Joints

Potential Cause(s)	Actions to Consider/Avoid	See Page
Excessive hand finishing	Check for mixture problems that would necessitate overfinishing.	220
	Improve construction practice.	
Trying to fix edge slump of low spots by hand manipulating concrete	Check for mixture problems that would cause edge slump.	217
	Improve construction practice.	
Mortar penetration into transverse joints (after hardening mortar prevents joint closure)	Mortar penetration occurs when paving against an existing previously placed lane; apply duct tape or other means to block the penetration of mortar into the transverse joints of the existing lane.	
Collateral damage from equipment, slipform paver tracks, screeds, etc.	Protect the edges of the slab from damage using gravel or dirt ramps.	
	Delay placement of the next phase of construction until the concrete gains sufficient strength.	

23. Dowels Are Out of Alignment

Potential Cause(s)	Actions to Consider/Avoid	See Page
Movement in dowel basket assemblies	Cover the dowel baskets with concrete ahead of the paver.	218, 248
	Use stakes to secure the baskets to the granular base.	
	Increase the length and number of stakes.	
	Use nailing clips on both sides of basket to secure the basket to the stabilized base.	
Dumping directly on dowel baskets	Deposit the concrete a few feet from the dowel basket to allow the concrete to flow around the dowel bars.	212
Poor aggregate gradation	Dowel insertion into mixtures with gap-graded aggregates does not work well; improve the aggregate grading.	176

Table 10-3. Preventing Problems That Are Observed at Some Time After Construction

Edge and Surface Issues

24. Clay Balls Appear at Pavement Surface

Potential Cause(s)	Actions to Consider/Avoid	See Page
Aggregate stockpile contamination generally caused by the following: • Haul trucks tracking clay and mud to stockpiles • Loader operator digging into dirt • Dirt coming from the quarry	Educate the loader operator on proper stockpile management techniques.	206
	Keep end-loader buckets a minimum of 2 ft off the ground.	
	Do not stockpile aggregates on soft foundations.	
	Stabilize the haul road at the plant site to avoid tracking contaminants.	
	Use belt placers at stockpiles rather than end loaders.	
	Check the aggregate producer's stockpiles.	
	Check for contamination in the hauling equipment.	
	Do not drive over a bridge to unload the aggregate.	
Mud being thrown into concrete trucks from muddy haul roads	Cover the trucks.	

25. Popouts

Potential Cause(s)	Actions to Consider/Avoid	See Page
Unsound aggregates	Use only aggregates that have been tested for chert, shale, and/or other undesirable fine particles.	45, 48
	Reduce vibration to minimize the flotation of particles.	
Alkali-silica reactions	Use non-alkali silica reactive aggregates.	31, 48, 141
	Use blended cements or SCMs proven to control ASR.	

26. Scaled Surface

Potential Cause(s)	Actions to Consider/Avoid	See Page
Premature finishing	Improve the finishing technique.	220
Improper finishing	Do not add water to the surface during finishing.	220
Over-finishing	Improve the finishing technique.	220
Frost related	Protect the concrete from freezing until a sufficient strength is achieved.	186, 228
	Concrete damaged by freezing must be removed and replaced.	
	Check the air content and spacing factor in the hardened concrete.	
	Premature salting; salts should not be applied to immature concrete.	
	Check the de-icing salts being used.	

27. Dusting Along Surface

Potential Cause(s)	Actions to Consider/Avoid	See Page
Adding water during finishing or finishing in bleed water	Prevent the addition of water during finishing.	220
	Delay finishing until after the dissipation of the bleed water.	

Edge and Surface Issues, continued

28. Concrete Blisters

Potential Cause(s)	Actions to Consider/Avoid	See Page
Premature closing of surface	Check for bleed water trapping.	220, 221
	Consider using a double burlap drag to open the surface.	
Extremely high/variable air content	Check for the consistency of the air content.	186
Vibrators too low	Check the vibrator depth.	215
Vibrator frequency too high	Reduce the vibrator frequency.	215
Over-sanded mixes	Increase the coarse aggregate.	176
Poor combined aggregate grading (gap grading)	Check the combined aggregate grading.	176

29. Surface Bumps and Rough Riding Pavement

Potential Cause(s)	Actions to Consider/Avoid	See Page
Placement operations	Construct and maintain a smooth and stable paver track line.	212, 215
	Check the string line tension and profile.	
	Maintain a consistent quantity of concrete in front of the paver.	
	Maintain a consistent forward motion; avoid a stop-and-go operation.	
	Check the paver tracks.	
	Check that the machine is level.	
	Check the sensors on the paver.	
	Verify that the paver electronics/hydraulics are functioning properly.	
Nonuniform concrete	Check the batching, mixing, and transport procedures for consistency.	176, 206, 207
	Check the aggregate grading and moisture contents for variations that might lead to wet and dry batches.	
Damming or rebound from dowel baskets	Lack of consolidation to achieve a uniform concrete density within the dowel basket area may create a rough surface because the concrete may settle or slough over the dowels.	215, 218, 248
	Check that the dowel baskets are secured.	
	The basket assembly deflects and rebounds after the slipform paver profile pan passes overhead and the extrusion pressure is released. The result is a slight hump in the concrete surface just ahead of the basket. Spring-back is more apt to occur on steeper grades and when there is too much draft in the pan; do not cut the basket spacer wires to prevent the basket from springing under the paver's extrusion pressure.	
	Do not overvibrate the concrete at the baskets in an effort to prevent basket movement.	

(continued on the following page)

Edge and Surface Issues, continued

29. Surface Bumps and Rough Riding Pavement, continued

Potential Cause(s)	Actions to Consider/Avoid	See Page
Reinforcement ripple	Address reinforcement ripple issues with well-graded aggregates and uniform concrete; consolidation is achieved at lower vibration energy and extrusion pressure.	106, 176
	Reinforcement ripple occurs when plastic concrete is restrained by the reinforcing bars, resulting in a ripple in the surface, with the surface slightly lower near each bar than in the area between the bars.	
	Longitudinal depressions are caused when longitudinal bars limit the restitution of the surface level behind the profile pan by restraining the rebound of the concrete beneath the bars.	
	Transverse ripple is caused by the transverse bars in the same way as longitudinal depressions, except that transverse ripple is found to be less noticeable than the prominent ridge caused by the damming effect of the transverse bars upon the upsurge flow of concrete behind the profile pan.	
	The prominence of surface rippling depends on the finishing techniques and depth of cover to the reinforcement, with less cover producing more prominent rippling.	
Vertical grades (exceeding 3 percent)	Lower the slump of the concrete; the need to make an adjustment depends upon whether it is difficult to maintain a uniform head of concrete in front of the paver.	212, 215
	Adjust the profile pan attitude, draft, or angle of attack. (When paving up a steeper grade, the pan elevation may be adjusted to about 25 mm [1.0 in.] below the surface grade. When paving down a steeper slope, the pan may be adjusted to about 25 mm [1.0 in.] above the surface grade. This adjustment must be made carefully to avoid reinforcement ripple, particularly a spring-back of the embedded dowel baskets.)	
	Adjust the staking interval; closely follow the grade and staking calculations for these circumstances to reduce the semi-chord effect enough to produce a smooth surface.	

30. Surface is Marred or Mortar is Worn Away

Potential Cause(s)	Actions to Consider/Avoid	See Page
Rained-on surface	Cover the slab to protect from rain.	229
	Remove the damaged surface by grinding.	
	Restore the surface texture (if required) by grinding.	
Improper curing type or application	Place a curing blanket or plastic sheets after the bleed water sheen disappears.	224
	Consider using a membrane-forming curing compound instead of sheets/blankets.	
Use of higher dosages (>25%) of GGBF slag	Do not add water to the mixture.	248
	Reduce the vibration energy to avoid bringing too much moisture to the surface; vibration at 5,000–8,000 vpm is sufficient for most well-graded mixtures.	
Over-sanded mixes	Increase the coarse aggregate.	176
Abrasion	Use a hard, wear-resistant aggregate.	50, 116
	Use a concrete mix with sufficient strength.	

Cracking

31. Cracking

Potential Cause(s)	Actions to Consider/Avoid	See Page
Applied loads	Keep construction traffic away from the slab edges; early loading by traffic or equipment causes higher edge stresses.	152, 157
	Keep public traffic away from the slab edges.	
Loss of support	Ensure that the subgrade and base have been properly prepared.	151, 157, 192, 237
	Ensure that the joints are properly filled and sealed where appropriate.	
Reflective cracks from stabilized bases	Isolate the slab from cracks in the base course by using bond breakers. (Acceptable bond breakers include two coats of wax-based curing compound, dusting of sand, bladed fines, asphalt emulsion, polyethylene sheets, and tar paper. Sheet goods are difficult to handle in windy or other harsh conditions.)	198
	Joint the base course to match the joints in the pavement.	
Slab/base bonding or high frictional restraint	Moisten the base course prior to paving (reduce the base temperature by evaporative cooling).	198
	Use a bond-breaking medium (see "Reflective cracks from stabilized bases," immediately above)	
	If the base is open-graded, use a choker stone to prevent the penetration of concrete into the base's surface voids.	
Mortar penetration into transverse joints (after hardening mortar prevents joint closure)	Mortar penetration occurs when paving against an existing previously placed lane; apply duct tape or other means to block the penetration of mortar into the transverse joints of the existing lane.	
Differential support condition created by frost heaving, soil settling, or expansive soils	Check base compaction, particularly above utility, culvert, and other trenches.	192, 196
	Proof roll the base.	
	Stabilize the subgrade soil.	
	Use selective grading techniques; cross-haul the soils to create smooth transitions between cut and fill sections and soil transitions.	
Misaligned dowel bars	Investigate whether the joints surrounding the crack have cracked and are functioning; misaligned or bonded dowels may prevent joint functioning, causing cracks.	218
	Designate personnel to ensure dowel alignment.	
Alkali-silica reactions	Avoid using reactive aggregates if possible.	31, 48, 141, 157, 179
	Use appropriate amounts of SCMs.	
	Use blended cements or SCMs proven to control ASR.	
	Use a low w/cm ratio.	
Chemical attack	Use a low w/cm ratio, maximum 0.45.	28, 157, 179
	Use an appropriate cementitious system for the environment.	
Frost related	Ensure that the air-void system of the in-place concrete is adequate.	49, 135, 136, 157, 179
	Use a low w/cm ratio.	
	Use frost-resistant aggregates.	
	Reduce the maximum particle size.	

Table 10-4. Assessing the Extent of Damage in Hardened Concrete

Problem	Nondestructive Testing Method(s)
1. Dowel bar alignment	Twin antenna radar Pulse induction (MIT-scan)
2. Pavement thickness	Impact-echo, radar
3. Pavement subgrade support and voiding	Impulse response Benkelman beam Falling weight deflectometer (FWD)
4. Concrete quality in pavement: a) Inclusions in pavement (clay balls) b) Honeycombing and poor concrete consolidation	Impulse radar Impulse response
5. Overlay debonding and separation: a) Traditional b) Advanced techniques	Hammer sounding Chain drag Impulse response Impact-echo, radar
6. Concrete strength	Rebound hammer (for comparative tests) Windsor probe

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This technical summary is based on chapter 10 of the IMCP Manual (Taylor, P.C., et al. 2006. *Integrated Materials and Construction Practices for Concrete Pavement: A State-of-the-Practice Manual*, Ames, Iowa, Iowa State University [FHWA HIF-07-004] [www.cptechcenter.org/publications/imcp/]) and was sponsored by the Federal Highway Administration. (References for any citations in this summary are at the end of the chapter.)

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CP Tech Center Mission

The mission of the National Concrete Pavement Technology Center is to unite key transportation stakeholders around the central goal of advancing concrete pavement technology through research, tech transfer, and technology implementation.

For More Information

Marcia Brink, Managing Editor
CP Tech Center, Iowa State University
2711 S. Loop Drive, Suite 4700
Ames, IA 50010-8664
515-294-8103, mbrink@iastate.edu
www.cptechcenter.org/

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Iowa State University