

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
Change in water content or aggregate grading	Check aggregate moisture contents and absorptions.
	Check for segregation in the stockpile.
	Make sure the batch water is adjusted for aggregate moisture content.
	Conduct batch plant uniformity tests.
Mix proportions	Check whether water was added at the site.
Mix proportions	Check batch equipment for calibration.
Admixture dosage	Check delivery ticket for correct admixture dosage.
Concrete temperature too high or too low	Adjust the concrete placement temperature.
Haul time	Check the batch time on the concrete delivery ticket. Haul times should not be excessive.

2. Loss of workability/slump loss/early stiffening

Potential cause(s)	Actions to consider/avoid
Dry coarse aggregates	Make sure the aggregate stockpile is kept consistently at saturated surface-dry (SSD) (use soaker hoses if necessary).
Ambient temperature increases	Do not add water.
	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.
Transport time too long	Use a mix design that includes slag or fly ash.
	Reject the load if greater than specified.
	Use retarder in the mixture.
Mix proportions have changed	Use an agitator rather than dump trucks.
	Check/monitor the moisture contents of the aggregate stockpiles.
False setting (temporary)	Check the batch weigh scales.
	Verify that aggregate gradations are correct.
	Check for changes in cementitious materials.
	Reduce Class C fly ash replacement.
Incompatibility	Change the type of water reducer.
	Try restoring plasticity with additional mixing.
	Contact the cement supplier.
	Check for changes in the cementitious materials.
Variation in air content	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.

Mixture and placement issues, continued

3. Mixture is sticky

Potential cause(s)	Actions to consider/avoid
Sand too fine	Change the sand grading.
Mix too sandy	Check the sand and combined aggregate grading.
Cementitious materials	Check the cementitious materials contents. (Mixtures containing ground granulated blast furnace [GGBF] slag and fly ash appear sticky but finish well and respond well to vibration energy.)
	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
Inconsistent concrete material— batching, mixing, placing	Check aggregate gradation; poorly graded mixtures may tend to segregate.
	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
Hot ingredients	Do not add water.
	Follow hot-weather concreting practice as appropriate.
	Chill the mix water or use ice.
	Shade and sprinkle the aggregate stockpiles.
Long haul times	Adjust the hauling operation to minimize haul times.
	Adjust paving time to off-peak traffic time if hauling through public traffic.
Hot weather	Follow hot-weather concreting practice as appropriate.
	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
Temperature changes	The air-entraining admixture dosage may need to be adjusted during hot/cold weather.
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.
	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.
Short or inadequate mixing	Verify sand quantity.
	Check the charging sequence.
	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
Incorrect or incompatible admixture types	Change types or brands of admixtures.
	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.
	Change the sequence of batching.
Mix proportions have varied or changed	Check/monitor the moisture contents of the aggregate stockpiles.
	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.
Poor plant configuration	Introduce aggregates together on the plant's belt feed (requires a multiple weigh hopper).
Poor aggregate grading	Use a more well-graded coarse and fine aggregate mixture.
	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.
	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.

Mixture and placement issues, continued

8. Mix sets early

Potential cause(s)	Actions to consider/avoid
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.
Admixture dosage	Check the dosage of chemical admixtures, particularly accelerators.
	Check the batching equipment.
Hot weather	Adjust the mix proportions.
	Use mix designs that include GGBF slag or fly ash.
	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
Excessive retarder dosage	Verify the proper batch proportions.
	Check the batching equipment.
	Reduce the dosage of the retarder.
Excessive water reducer dosage	Verify the proper batch proportions.
	Reduce the dosage of the water reducer.
Retarder not dispersed well	Improve mixing to disperse the retarder.
Supplementary cementitious materials interference	Reduce GGBF slag content; GGBF slag in excess of 25 percent can cause a dramatic increase in set time.
	Eliminate/reduce fly ash content in the mix.
Cold placement temperature	Follow cold-weather concreting practices if appropriate.
Organic contamination	Verify the proper batch proportions.
	Check for contamination of water and aggregates.

10. Supplier breakdown, demand change, raw material changes

Potential cause(s)	Actions to consider/avoid
Cement	Refer to backup lab mixes if conditions were anticipated.
	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.
	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.
	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.
	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
Fibers not thoroughly dispersed in mix	If added in bags, check the timing of addition and subsequent mixing.
	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.

12. Concrete surface does not close behind paving machine

Potential cause(s)	Actions to consider/avoid
Insufficient volume contained in the grout box	Place more material in front of the paver; consider using a spreader.
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.)
The fine/coarse aggregate volume or paste volume is too low	Check mixture proportions, particularly aggregate gradations. 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.
	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
Excessive concrete slump loss	Check for slump loss and mixture or weather changes.
	See No. 2: Loss of workability/slump loss/early stiffening.
Insufficient concrete slump	Check the mixture proportions.
Angular fine aggregate (manufactured sand)	Replace a portion of the manufactured sand with natural sand.
Paver speed too high	Slow the paver.
Coarse aggregate is segregated	Check the stockpile.
Coarse aggregate is gap-graded	Check the combined aggregate grading.
	Blend the aggregate with intermediate aggregates to achieve a uniform combined grading.

14. Paving leaves vibrator trails

Potential cause(s)	Actions to consider/avoid
Vibrator frequency too low	Check if the seals on the vibrators are leaking.
Vibrator frequency too high	Lower the vibrator frequency.
Paver speed too slow	Increase the paver speed.
Nonworkable concrete mix	Review concrete workability field test data.
	See No. 2: Loss of workability/slump loss/early stiffening.
Oversanded mixes	Increase the coarse aggregate.
Poor combined aggregate grading	Check the combined aggregate grading.

15. Slab edge slump

Potential cause(s)	Actions to consider/avoid
Poor and/or nonuniform concrete (gap-graded aggregate, high water/cement ratio, etc.)	Verify the mix design and batching procedures.
	Check the aggregate grading—use a well-graded combined aggregate gradation.
Inadequate operation of equipment	Check the construction procedures.
	Adjust the outside vibrator frequency.
	Adjust the side form batter.
Improper equipment setup	Adjust the overbuild.
	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
Hot weather may induce premature stiffening	Follow hot-weather concreting practices if appropriate.
	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.
	Add an additional vibrator near the slipformed edge.
Poor workability	Check for changes in the aggregate grading.

17. Plastic shrinkage cracks

Potential cause(s)	Actions to consider/avoid
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.
	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.

After the Concrete Has Set

Other problems, such as rapid stiffening, may be observed only after the concrete has been placed. In such cases, the material may have to be removed, or it may be accepted as long as future deliveries are corrected.

In the First Days after Placing

Some problems, such as early-age cracking, are observed at some time between final set and up to a few days after placing (Table 10-2). Some remedial work may be possible (and required), and steps should be taken to prevent their recurrence.

Table 10-2. Problems observed in the first days after placing

Strength

18. Strength gain is slow

Potential cause(s)	Actions to consider/avoid
Cold temperature during/after placement	Heat the mix water.
	Use burlap/insulating blankets for protection from freezing.
	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.
Mix proportions or materials have changed	Monitor the slab temperature with maturity sensors.
	Check/monitor the moisture contents of the aggregate stockpiles.
	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
Cementitious materials	Check for changes in the cementitious materials.
	Check that the correct materials have been loaded into the cement/fly ash/slag silos.
Water	Check the water content.
	Verify the aggregate moisture contents and batch weights.
Change in sand grading	Check the sand stockpile to see whether the grading has changed.
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.
	Check for worn mixer blades.
	Check for mixer overloading.
	Batch smaller loads.
	Check the sequencing of batching.
	Check for mixing time consistency.
Plant operations	Conduct batch plant uniformity testing.
	Verify the acceptability of the batching and mixing process.
	Check for adequate mixing times.
Testing procedures	Check if water was added to the truck.
	Verify proper making, curing, handling, and testing of strength specimens. (Flexural strength specimens are particularly vulnerable to poor handling and testing procedures.)
	Verify the machine acceptability testing.
Air-void clustering	Test the cores sampled from the pavement to verify acceptance.
	Use a Vinsol resin-based air-entraining admixture.
	Avoid retempering.
	Increase the mixing time.

Cracking

20. Early-age cracking

Potential cause(s)	Actions to consider/avoid
Concrete mixture	Check the combined aggregate grading.
	Examine the fine aggregates; fine aggregates may be too fine and angularity may cause harsh finishing (i.e., manufactured sands).
	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.
Sawing	Consider using an accelerator in cold weather.
	Saw as early as possible but avoid excessive raveling.
	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.
Curing	Use HIPERPAV to model stress versus strength gain for conditions to determine the optimum sawing time.
	Improve/extend curing.
	Apply the curing compound at a higher rate.
Insufficient joint depth	Apply the curing compound sooner.
	Use blankets between placing and saw-cutting.
	Check the saws for depth setting.
	Check the saw blade for wear (carbide blades).
Excessive joint spacing	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.
	Reduce spacing between the joints.
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)	Slabs are too wide in relation to thickness and length; add intermediate joints.
	Maintain a reasonable length-width ratio.
	Check the moisture state of base.
	Improve or extend curing.
	Minimize the shrinkage potential of the concrete mixture.
	Cover the slab, particularly when night/day temperatures vary widely.

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20. Early-age cracking, continued

Potential cause(s)	Actions to consider/avoid
High temperature	Cool the raw materials before mixing the concrete: shade, spray, ice, liquid nitrogen
	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 (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 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 in. 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).
	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.
Cold front with or without rain shower	Use early-entry sawing to create a weakened plane prior to temperature contraction.
	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
Sawing too soon	Wait longer to saw.
	Blank out transverse tining at transverse contraction joints.
Saw equipment problem	Blade selection for the concrete (coarse aggregate type) may be inadequate.
	A bent arbor on the saw causes the blade to wobble.
Sawing too fast	The second saw cut can go back and forth; consider a single-cut design.
	Slow down.

22. Spalling along joints

Potential cause(s)	Actions to consider/avoid
Excessive hand finishing	Check for mixture problems that would necessitate overfinishing.
	Improve construction practice.
Trying to fix edge slump of low spots by hand manipulating concrete	Check for mixture problems that would cause edge slump.
	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
Movement in dowel basket assemblies	Cover the dowel baskets with concrete ahead of the paver.
	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.
Poor aggregate gradation	Dowel insertion into mixtures with gap-graded aggregates does not work well; improve the aggregate grading.

Some Time after Construction

Finally, some problems are observed only after the pavement has been in place for some time (Table 10-3).

In these cases, some repair may be possible or replacement may be required. Table 10-3 provides guidelines on how to prevent such problems in future construction.

Table 10-3. Preventing problems that are observed some time after construction

Edge and surface issues

24. Clay balls appear at pavement surface

Potential cause(s)	Actions to consider/avoid
Aggregate stockpile contamination generally caused by the following: <ul style="list-style-type: none"> • 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.
	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.
Mud being thrown into concrete trucks from muddy haul roads	Cover the trucks.

25. Popouts

Potential cause(s)	Actions to consider/avoid
Unsound aggregates	Use only aggregates that have been tested for chert, shale, and/or other undesirable fine particles.
	Reduce vibration to minimize the flotation of particles.
Alkali-silica reactions (ASRs)	Use non-alkali silica reactive aggregates.
	Use blended cements or supplementary cementitious materials (SCMs) proven to control ASR.

26. Scaled surface

Potential cause(s)	Actions to consider/avoid
Premature finishing	Improve the finishing technique.
Improper finishing	Do not add water to the surface during finishing.
Overfinishing	Improve the finishing technique.
Frost related	Protect the concrete from freezing until a sufficient strength is achieved.
	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 deicing salts being used.

27. Dusting along surface

Potential cause(s)	Actions to consider/avoid
Adding water during finishing or finishing in bleed water	Prevent the addition of water during finishing.
	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
Premature closing of surface	Check for bleed water trapping.
	Consider using a double burlap drag to open the surface.
Extremely high/variable air content	Check for the consistency of the air content.
Vibrators too low	Check the vibrator depth.
Vibrator frequency too high	Reduce the vibrator frequency.
Oversanded mixes	Increase the coarse aggregate.
Poor combined aggregate grading (gap grading)	Check the combined aggregate grading.

29. Surface bumps and rough riding pavement

Potential cause(s)	Actions to consider/avoid
Placement operations	Construct and maintain a smooth and stable paver track line.
	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.
Nonuniform concrete	Verify that the paver electronics/hydraulics are functioning properly.
	Check the batching, mixing, and transport procedures for consistency.
Damping or rebound from dowel baskets	Check the aggregate grading and moisture contents for variations that might lead to wet and dry batches.
	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.
	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.

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29. Surface bumps and rough riding pavement, continued

Potential cause(s)	Actions to consider/avoid
Reinforcement ripple	Address reinforcement ripple issues with well-graded aggregates and uniform concrete; consolidation is achieved at lower vibration energy and extrusion pressure.
	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.
	Adjust the profile pan attitude, draft, or angle of attack. (When paving up a steeper grade, the pan elevation may be adjusted to about 1.0 in. below the surface grade. When paving down a steeper slope, the pan may be adjusted to about 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
Rained-on surface	Cover the slab to protect from rain.
	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.
	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.
	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.
Oversanded mixes	Increase the coarse aggregate.
Abrasion	Use a hard, wear-resistant aggregate.
	Use a concrete mix with sufficient strength.

Cracking

31. Cracking

Potential cause(s)	Actions to consider/avoid
Applied loads	Keep construction traffic away from the slab edges; early loading by traffic or equipment causes higher edge stresses.
	Keep public traffic away from the slab edges.
Loss of support	Ensure that the subgrade and base have been properly prepared.
	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.)
Slab/base bonding or high frictional restraint	Moisten the base course prior to paving (reduce the base temperature by evaporative cooling).
	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.
	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.
	Designate personnel to ensure dowel alignment.
Alkali-silica reactions	Avoid using reactive aggregates if possible.
	Use appropriate amounts of SCMs.
	Use blended cements or SCMs proven to control ASR.
Chemical attack	Use a low water/cementitious materials (w/cm) ratio.
	Use a low w/cm ratio, maximum 0.45.
	Use an appropriate cementitious system for the environment.
Frost related	Ensure that the air-void system of the in-place concrete is adequate.
	Use a low w/cm ratio.
	Use frost-resistant aggregates.
	Reduce the maximum particle size.

Table 10-4 is a listing of some of the nondestructive testing (NDT) techniques available to assess the extent of damage in hardened concrete.

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-DOWEL-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

References

Harrington, D., M. Ayers, T. Cackler, G. Fick, D. Schwartz, K. Smith, M. Snyder, and T. Van Dam. 2018. *Guide for Concrete Distress Assessments and Solutions: Identification, Causes, Prevention, and Repair*. National Concrete Pavement Technology Center, Ames, IA.