Pavement & Materials Partnering Committee
Decision Document
Surface Skid Resistance Test for Concrete Pavement
Acceptance April 10, 2023

Problem Statement

Skid test as acceptance in Section 40 of the Standard Specifications is redundant since the texture of concrete pavements is very prescriptive.

Background

Pavement surface textures play an important role in the performance of concrete pavements. Friction between the tire and pavement surface is a contributing factor for roadway safety, noise, and ride quality. To help manage concrete pavement texture at the project level, Caltrans Section 40 specifies longitudinal tining, diamond grinding, and grooving as acceptable surface textures. Previous studies and performance data have shown these textures provide Caltrans favorable skid resistance over time.

In addition, for concrete pavement project acceptance, Section 40 specifies the use of CT 342 Method of Test for Surface Skid Resistance with the California Portable Skid Test. This test equipment was developed by Caltrans in late 1950s and the current skid resistance acceptance value of 0.30 was established in 1969.The engineering used to establish current CT 342 project level acceptance values does not apply to today's roadway conditions. One of the greatest deficiencies is that CT 342 values do not represent the anti-lock braking systems (ABS). In the1990's ABS became standard-issue on vehicles in the U.S. When ABS equipped vehicles became predominate on the State Highway System, the validity of CT 342 values developed over 50 years ago became more questionable. The widespread implementation of longitudinal textures and curing compounds, raise additional questions about the applicability of the Caltrans skid resistance acceptance values and the use of CT 342 as a project acceptance tool. No other state DOT specifies skid resistance or friction testing for concrete pavement acceptance at the project level – only Caltrans. Many state DOTs conduct skid resistance testing at the network level as part of their Pavement Friction Management.

A clear relationship between CT 342 values and accident rates on California roadways has not been established. This is not just a California issue. As documented in the AASHTO Guide for Pavement Friction (2022), although a basic relationship exists between pavement friction and wet-crash rates, no specific threshold values have been established for pavement friction that make a pavement more or less safe. Since accidents would likely happen years after projects are constructed, concrete pavement project level friction would no longer be valid so a network level pavement management friction would have to be established for friction monitoring regardless pavement type. Pavement friction demand, which is specific to the characteristics of a particular roadway, must be considered when establishing any sort of threshold.

Pavement friction demand is dictated by site conditions (such as longitudinal grade, superelevation, radius of curvature, terrain, climatic conditions), traffic characteristics (volume and mix of vehicle types), and driver behavior (prevailing speed, response to conditions, etc). According to Merritt et al. (2015), these conditions are continually changing over time and are different for every roadway, making it difficult to establish a "one size fits all" friction threshold.

Since the specification for texture is prescriptive, the requirement to accept concrete pavements based on skid resistance should be eliminated, especially given the issues associated with resources and the fact that California is the only state with such acceptance requirement for concrete pavements. Section 40-1.03H(3) says, "The tines must be from 3/32 to 1/8 inch wide, spaced on 3/4-inch centers, and [the equipment must] have enough length, thickness, and resilience to form grooves approximately 3/16 inch deep." It is known that if the pavement does not have any texture, it will not have sufficient friction. Pavement texture should be accepted based on a visual evaluation and random checking of the depth and width of the tines.

Recommendation

Revise Section 40 language related to concrete pavement friction. Below are the proposed modifications.

40-1.01D Quality Assurance

40-1.01D(1) General

If the pavement quantity is at least 2,000 cu yd, provide a QC manager.

Core pavement as described for thickness, bar placement, and air content.

Provide material, labor, and equipment that meets the initial curing requirement to assist the Engineer in fabricating, curing and handling specimens for the Department's modulus of rupture and compressive strength testing. Failure to maintain the proper curing environment during initial cure will not be basis for rejection of samples, dispute resolution, or claim against the Department. Secure the initial curing equipment at all times to protect against theft and damage.

~~Allow at least 25 days for the Department to schedule testing for the coefficient of friction. Notify the Engineer when a lane or lanes are scheduled to be opened to traffic and when the pavement is ready for testing, which is the latter of:~~

~~1. 7 days after paving~~
~~2. When the pavement has attained a modulus of rupture of at least 550 psi~~

~~The Department tests for the coefficient of friction within 7 days of receiving notification that the pavement is ready for testing.~~

40-1.01D(8) Department Acceptance

40-1.01D(8)(a) General

The Department tests the concrete pavement under the test methods and at the frequencies shown in the following table:

Department Acceptance Testing Frequency

Quality characteristic	Test method		Minimum testing frequency[a]
	CRCP	JPCP	
Air content[b]	California Test 504		1 day's paving
Compressive strength at 42 days	California Test 521		1,000 cu yd
Dowel bar placement	--	Measurement	700 sq yd
Tie bar placement	--	Measurement	4,000 sq yd
~~Coefficient of friction~~	~~California Test 342~~		~~1 day's paving~~
Thickness	California Test 531		1,200 sq yd

[a]A single test represents no more than the frequency specified.
[b]Tested only if air entrainment is specified.

Concrete Pavement Requirements for Acceptance

Quality characteristic	Test method		Requirement
	CRCP	JPCP	
Air content	California Test 504		±1.5 % of the specified value[a]
Compressive strength at 42 days (min, psi)	California Test 521		650[b] equivalent modulus of rupture to compressive strength
Bar reinforcement depth tolerance at joints (min)	Field measurement		1/2 inch below the saw cut depth
Dowel bar placement tolerances[c]: Horizontal offset (inch) Longitudinal translation (inch) Horizontal skew (max, inch) Vertical skew (max, inch) Vertical depth	--	Field measurement	±1 ±2 5/8 5/8 The minimum distance measured from the concrete pavement surface to any point along the top of the dowel bar must be: *DB* + 1/2 inch where: *DB* = 1/3 of the pavement thickness or the saw cut depth in inches, whichever is greater The maximum distance below the depth shown must be 5/8 inch
Tie bar placement tolerances[c]: Horizontal and vertical skew (max, inches) Longitudinal translation (inches) Horizontal offset (embedment, inches) Vertical depth	--	Field measurement	5-1/4 ±2 ±2 1. At least 1/2 inch below the bottom of the saw cut 2. At least 2 inches from any point along the bar to the pavement surface or bottom
~~Coefficient of friction (min):~~ ~~Concrete pavement~~ ~~Ramp termini~~	~~California Test 342~~		~~0.30~~ ~~0.35~~
Pavement smoothness	California Test 387, AASHTO R 56, and AASHTO R 57		1. No area of localized roughness greater than 160 in/mi, except when grinding existing pavement 2. For Mean Roughness Index (MRI) acceptance, refer to the Concrete Pavement Smoothness Selection Table in section 40-1.01D(8)(c)(iii)
Thickness tolerance[d] (max, foot)	California Test 531		0.01 foot deficient of the thickness shown

[a]If no value is specified, the air content must be within ±1.5 % of the value used for your authorized mix design.
[b]Average of the individual test results of 3 cylinders.
[c]Placement tolerance is measured relative to the completed joint.
[d]See section 40-1.01D(8)(c)(iv) for additional thickness requirements.

40-1.03H(3) Final Finishing

After completing preliminary finishing, round the edges of the initial paving widths to a 0.04-foot radius. Round the transverse and longitudinal construction joints to a 0.02-foot radius.

Texture the pavement before curing it. Perform the initial texturing with a burlap drag or broom device that produces striations parallel to the centerline. Perform the final texturing with a spring-steel tined device that produces grooves parallel with the centerline.

Construct longitudinal grooves with a self-propelled machine designed specifically for grooving and texturing pavement. The machine must have tracks to maintain constant speed, provide traction, and maintain accurate tracking along the pavement surface. The machine must have a single row of rectangular spring steel tines. The tines must be from 3/32 to 1/8 inch wide, spaced on 3/4-inch centers, and have enough length, thickness, and resilience to form grooves approximately 3/16 inch deep. The machine must have horizontal and vertical controls. The machine must apply a constant downward pressure on the surface of the pavement during texturing. The operation must not cause raveling.

Construct grooves over the entire pavement width in a single pass except do not construct grooves 3 inches from the pavement edges and longitudinal joints. The final texture must be uniform and smooth. Use a guide to properly align the grooves. The grooves must be parallel and aligned to the pavement edge across its width. The grooves must be from 1/8 to 3/16 inch deep after the pavement has hardened.

590

SECTION 40 CONCRETE PAVEMENT

For irregular areas and areas inaccessible to the grooving machine, you may construct grooves using the hand method. Hand-constructed grooves must comply with the specifications for machine-constructed grooves.

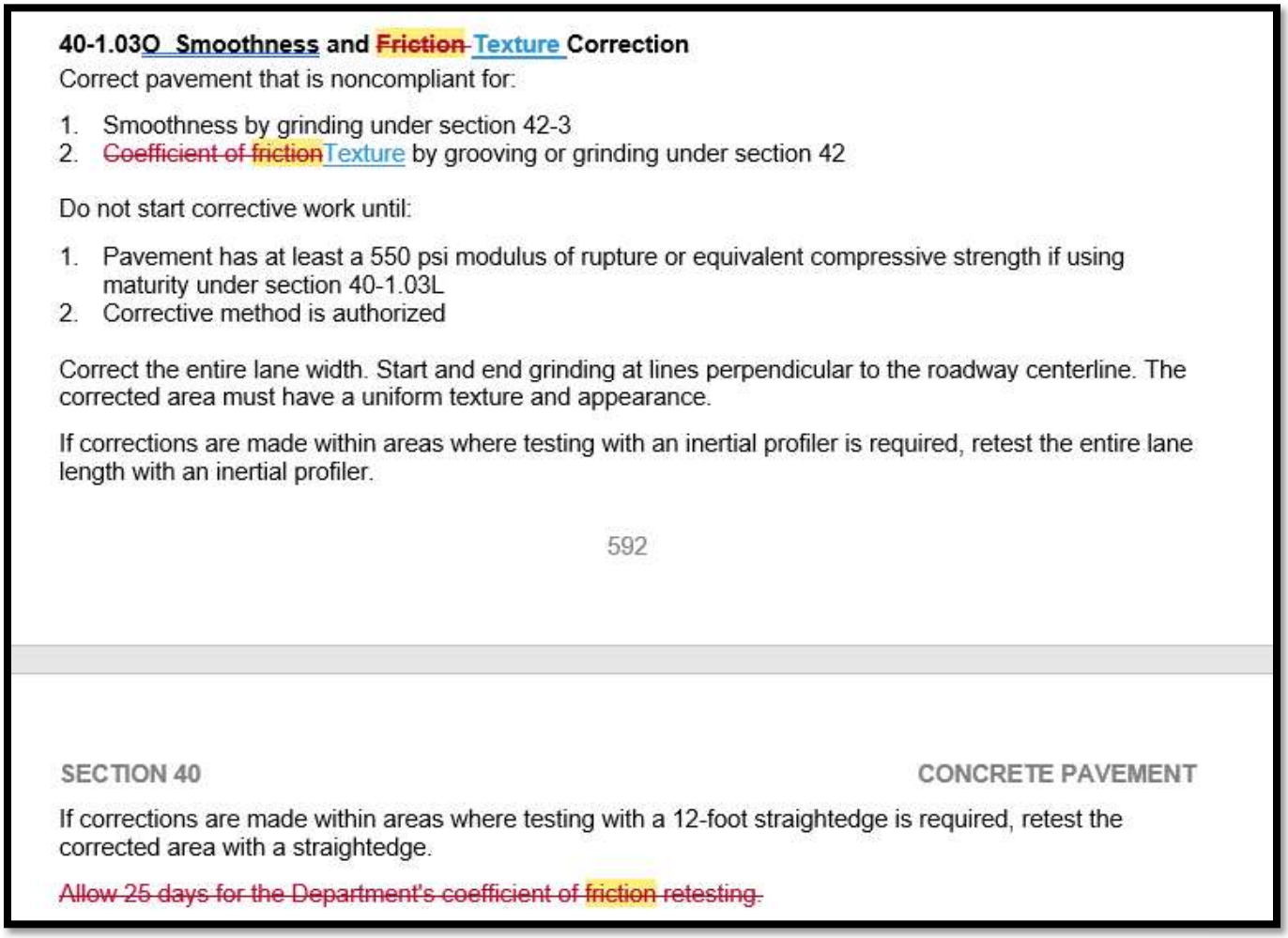
~~Initial and final texturing must produce a coefficient of friction of at least 0.30. Do not open a lane or lanes to traffic unless the coefficient of friction is at least 0.30.~~

For ramp termini, use heavy brooming normal to the ramp centerline ~~to produce a coefficient of friction of at least 0.35~~.

40-1.03J Protecting Concrete Pavement

Maintain the concrete pavement surface temperature at not less than 40 degrees F for the initial 72 hours.

Protect the surface from activities that cause damage and reduce the texture ~~or coefficient of friction~~. Prevent soil, gravel, petroleum products, concrete, or asphalt mixes from being deposited on the pavement surface.



40-1.03O Smoothness and ~~Friction~~ Texture Correction

Correct pavement that is noncompliant for:

1. Smoothness by grinding under section 42-3
2. ~~Coefficient of friction~~Texture by grooving or grinding under section 42

Do not start corrective work until:

1. Pavement has at least a 550 psi modulus of rupture or equivalent compressive strength if using maturity under section 40-1.03L
2. Corrective method is authorized

Correct the entire lane width. Start and end grinding at lines perpendicular to the roadway centerline. The corrected area must have a uniform texture and appearance.

If corrections are made within areas where testing with an inertial profiler is required, retest the entire lane length with an inertial profiler.

592

SECTION 40 CONCRETE PAVEMENT

If corrections are made within areas where testing with a 12-foot straightedge is required, retest the corrected area with a straightedge.

~~Allow 25 days for the Department's coefficient of friction retesting.~~

In addition to Section 40 changes, Caltrans Construction will need to update their Construction Manual to reflect the specification changes.

Fiscal Impact

Reduction in CT 342 testing will reduce the workload and equipment costs for Caltrans. Note that Section 40 language was changed to say that Caltrans would perform one skid testing per paving day but that is not feasible given the needed resources.

Contractors may see minor cost reductions for concrete pavement work due to the reduced coordination and related word involved with CT 342.

Stakeholder Impact

There are no known stakeholder impacts to adopting the recommendation.

Policy Impact

There are no known Caltrans policy impacts to adopting the recommendation.

Risks

Adopting the recommendation in this Decision Document does not involve any known risk. Risks related to a "Do Nothing" approach would continue to lack consistency with other DOTs and avoid potential long disputes.

Proposed Implementation Schedule

Section 40 language would be revised through the next update to the Standard Specifications. Since this could take one year or more given changes in the specification publication process, it is recommended that a Construction Procedure Directive (CPD) be issued to avoid the excessive use of NSSPs and explain the change to the Caltrans field staff, contractors, and testing laboratory personnel. Caltrans Office of Concrete Pavements will add this revision to their statewide concrete pavement training priorities.

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