2010

Review of Caltrans Concrete Pavement Sealed and Unsealed Pavement Performance

Field Review Observations

On August 24-25, 2010 a joint Caltrans and Industry group met to discuss the state-0f-the –practice of joint sealing in California. After a brief overview of the situation, nine of the 11 participants spent 1 ½ days reviewing Caltrans selected sites which depicted the sealed and unsealed pavement performance of sections constructed over the past 50 years.

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AMERICAN CONCRETE PAVEMENT ASSOCIATION

ACPA
Larry Scofield
10/15/2010

Introduction

On August 24-25th, 2010 representatives from Caltrans headquarters and Districts 7 & 8 met with representatives from the concrete industry to discuss and review the performance of concrete pavement joint sealants in California. This effort consisted of a meeting on the morning of the first day followed by 1 ½ days of field reviews. The attendee list is included in Appendix 1. Photos of some of the joints are included in Appendix 2.

The meeting was organized by Mr. Bill Farnbach of Caltrans and Mr. Craig Hennings of the ACPA Southwest. Caltrans transported the participants in a van so everyone could review and discuss the sites at the same time. Mr. Farnbach provided 14 handouts to the group and described the purpose of the meeting and field reviews. He provided a presentation reviewing photos of various joint conditions existing within the state.

The meeting was essentially a result of the recent draft Pavement Policy Bulletin PPB 10-X5 approved May 12, 2010. This bulletin made the recommendations shown below:

Pavement Policy Bulletin Recommendations

- Contraction joints (longitudinal and transverse) and construction joints are not to be sealed in the following climate regions: Central Coast, Inland Valley, South Coast, Desert
- Joint seals should be applied to these locations as part of a future preservation program when the joint widths exceed ¼ inch, typically in 15 to 25 years.
- Contraction and Construction Joints to be sealed in all other climates.

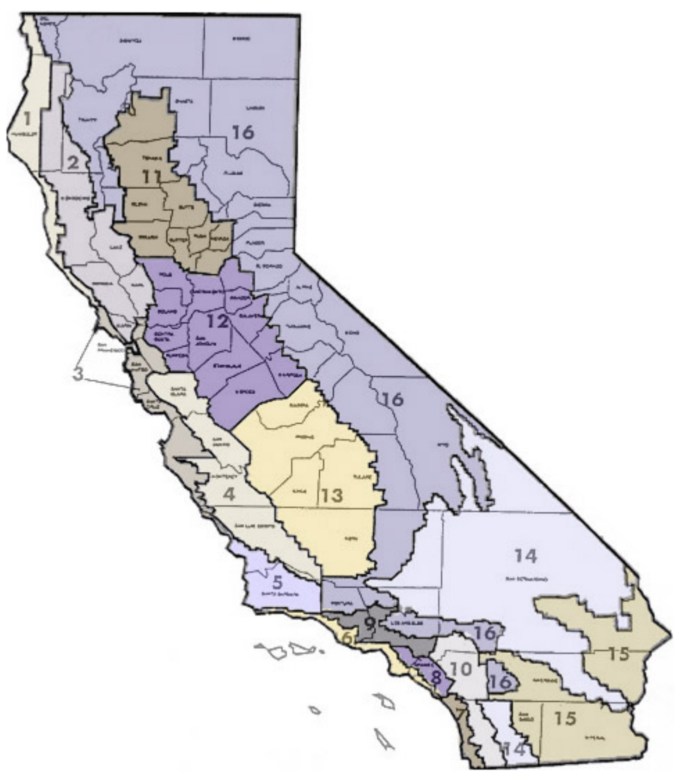

Figure 1 California Climate Regions as Defined by Title 24

This policy was developed on the basis that for over 50 years (1940 to 1990), Caltrans did not seal joints on concrete pavements. Beginning in early 1990's Caltrans began to seal joints for all new pavements. This added to the cost of the pavement, but was intended to keep incompressibles out of joints and extend pavement life. Caltrans is now reconsidering this decision based on the recent FHWA study and the movement of some states to discontinue sealing joints.

Current Caltrans Concrete Pavement Details

- In the design process, headquarters provides standards and guidelines but the districts have latitude to modify on a project specific basis
- Joint spacing is random 12, 15, 13, 14 ft with an average spacing of 13.5 ft.
- The aggregate top size is 1 inch, and up to 50% flyash replacement is allowed.
- A 3/8 inch reservoir cut is typically specified although they have several joint details including a single saw cut narrow joint design.
- The sealant material selection is left up to the contractor; the sealant can be hot pour, silicone, or compression seal based on which the contractor chooses to use.
- The only sealant construction requirements are that it will be installed in accordance with the manufacturer's recommendations.

Caltrans Highway Design Manual Rigid Pavement Performance Factors

The design manual indicates the following performance factors to define when a concrete pavement will be rehabilitated. Table 1 indicates the performance factors. Table 2 indicates the expected performance periods for each of the sealant types listed in the design manual.

Table 1 Rigid pavement Performance Factors

Performance Factor	Value
All Pavements	
Design Life	Determined per Topic 612[1]
End of Life Roughness	160 in/mile (IRI)
JPCP	
Transverse Cracking @ end of life	10% of slabs
Longitudinal Cracking @ end of life	10% of slabs
Corner Cracking @ end of life	10% of slabs
Average Joint Faulting @ end of life	0.10 inch

[1] Note: Caltrans uses a 20 yr and a 40 yr design for PCCP. For roads over 150,000 ADT a 40 yr design is used. They also use a 55 year analysis period for LCCA.

Table 2 Expected Performance Period for Sealants

Sealant Type	Expected Performance Period (years)
Asphalt Rubber	3 - 5
Silicone	5 - 7
Compression Seal	8 - 12

Chronology of Caltrans Pavement Design Changes as Described by Bill Farnbach

- **1950s:** 15 ft, non-skewed transverse joints; non-dowelled; no tie bars; unsealed joints
- 1**960** and **70s:** skewed joints spaced at 12,13,19,18 ft and unsealed
- Pavement Design Changes in 77, 81,84,88
- **1980**s: Changed joint spacing to 12, 15, 13, 14 ft. Still unsealed Joints
- **1990:** Century Freeway used tie bars, one of early jobs to use tie bars
- **1998:** Introduced use of flyash at 15% substitution then moved to 25% in XXXX
- **1999:** Introduced dowel bars and sealed joints, eliminated skewed joints
- **2004:** Introduced the use of longitudinal isolation joints to separate existing pavement from new lanes (old joint spacing different from current designs).
- **2009:** Introduced 50% allowable flyash replacement

Development of the California Freeway System

Figure 2 indicates the number of miles of concrete pavement placed by year. As indicated, much of the Caltrans network was constructed between 1959 and 1974.

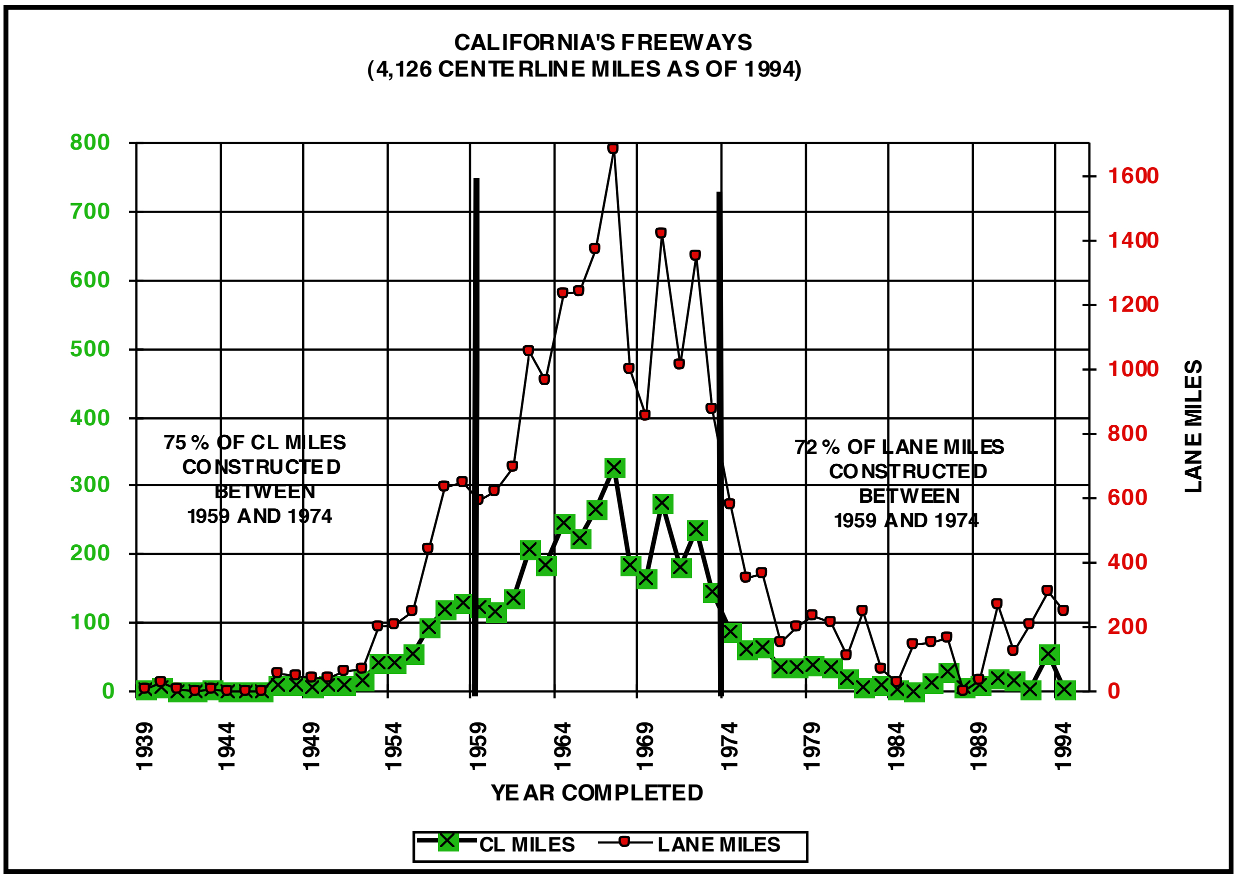

Figure 2 Miles of Concrete Pavement Constructed by Year

(Note: Information not Presented at the Meeting)

Questions Presented to Industry by Caltrans at the Start of the Meeting

- Desired joint width

- Performance Life of Sealed Pavements versus Unsealed Pavements
- Performance Life of Sealant Materials
- Desired Maintenance Practices; When to Reseal and What Techniques to Use
- Should Reservoir Cuts be used
- What is the Desired Joint Spacing
- What are the Best Procedures for Spall Repair
- How Does Flyash and Mix Designs Impact Sealant/Joint Performance
- Longitudinal Striping Not Consistent with DBR Placement Locations

Discussion led by Bill Farnbach Upon Conclusion of Field Trip

- Provide recommendations on: sealant installation and maintenance practices; performance periods of each of the sealants; installation costs; limitations of different products
- ACPA consider using Relative Cost Task Force Survey to address cost using LCCA approach
- Caltans can consider using the CPR4(?) Software to Address User Costs
- Cost should consider different traffic levels, climate, sealed versus unsealed and filled versus sealed
- Caltrans has a goal to have 100 yr pavements
- There is a need to construct test sections on both new and existing projects. I-5 and Hwy 118 has an active project that can be investigated for the possibility of constructing sealant test sections. The sealant installation would probably occur this October.
- A workshop the day before the sealant test section construction would be advantageous to improve awareness and training. This location is also within 4 hrs drive time for approximately 2/3 of the state so is a good location. This effort could also be turned into a webinar and used nationally.
- Bill advised that he thought the biggest hole they have is the resealing process. That is, it is not done at all or else it is just a quick overband.
- There is a need to have a comprehensive policy on constructing and maintaining joints.
- The Legislature holds the maintenance division to performance standards. The measure of performance is retired miles of distressed pavement. Currently there are only two factors considered, cracking and ride. The process of installing joint sealant has no immediate impact on either of the performance factors so the motivation for maintenance is limited. They would be expending resources to conduct the work but the measurements would not indicate any immediate benefit.
- The current Caltrans distress survey process only evaluates the outside lane. It does not consider the other lanes.
- How do you define when a sealant should be replaced?

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Larry Scofield Thoughts

- Joint Sealing, if done, should occur at the time construction for several reasons:

  - Incompressibles enter during the construction process need to be removed before opening to traffic
  - Concrete is the weakest when new and is the most vulnerable to spalling from incompressibles
  - The user cost has already been absorbed as part of the construction process, any subsequent interventions would incur additional user costs. What if the interval is not 15 to 25 years but instead only 5 to 10 years.
  - How is the joint opening width to be measured on a heavily trafficked roadway in practice. No one does it now?
- The sliver spalls typically are a result of the construction process and do not affect pavement roughness and typically are not considered in pavement performance.
- Many of the highways were in amazing condition considering their age and traffic levels for both the sealed and unsealed conditions.
- Need to address the training and education issues
- Need to address the disconnect between the construction of joints and the maintenance of joints; particularly the user cost impacts by having re-occurring maintenance sealing operations and the impact caused by the overbanding process on subsequent rehabs.
- Need to consider contracted sealant maintenance that can be accomplished properly with the necessary equipment. It is probably not realistic that Caltrans can get equipment to saw and seal joints.
- The only observable difference I could tell between the sealed and unsealed sections is the shoulder joint for ac shoulders. It was typically separated from the concrete by ½ to one inch. The question arises is whether this is due to erosion of the base.
- Based on the one snap shot in time review, it is not possible to know whether a sealant installation would have impacted fault levels since many of the sections had been ground.
- It would be very helpful for Caltrans to construct sealant test section experiments on pavements of different ages varying from new construction to 10 yrs old, 20 yrs old, etc. This would not provide information at the present time but would provide data for future decisions.
- Do to the differences in materials and design between the older existing pavements and the current pavements, they should be considered and evaluated separately.
- Caltrans should adopt a uniform 13.5 ft non-skewed joint spacing.
- There should be some discussion regarding how best to connect lanes of different joint spacings

Appendix 1 Participant Listing

Name	Organization	Email
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Appendix 2 Photos of Joint Conditions

Figure 1

Figure 2

Appendix 2 Photos of Joint Conditions

Figure 3


Figure 4

Appendix 2 Photos of Joint Conditions

Figure 5

Appendix 2 Photos of Joint Conditions

Figure 6

Appendix 2 Photos of Joint Conditions

Figure 7

Appendix 2 Photos of Joint Conditions

Figure 8

Appendix 2 Photos of Joint Conditions

Figure 9

Appendix 2 Photos of Joint Conditions

Figure 10

Appendix 2 Photos of Joint Conditions

Figure 11

Appendix 2 Photos of Joint Conditions

Figure 12

Figure 13 Silicone Sealant Wear from Tires on Old Sealant

Appendix 2 Photos of Joint Conditions

Figure 14 Shoulder Distress

Figure 15 Shoulder Distress

Appendix 2 Photos of Joint Conditions

Figure 16 Shoulder Distress

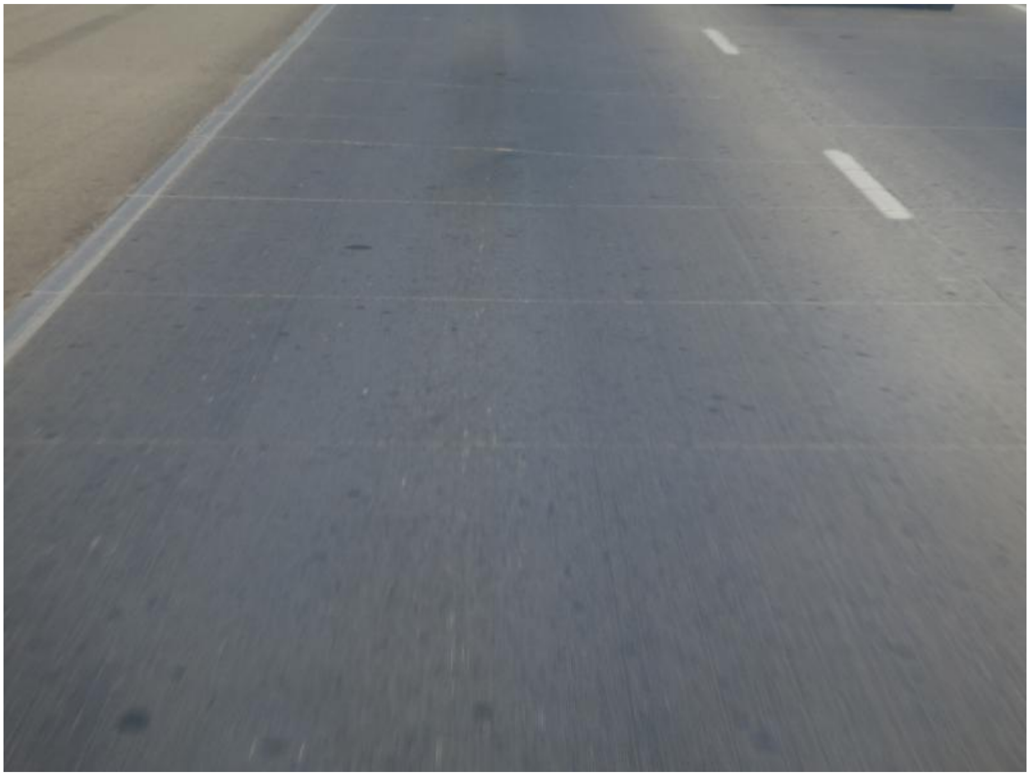

Figure 17 Faulting Looking Back

Appendix 2 Photos of Joint Conditions

Figure 18 Misaligned Joints

Figure 19 Jog in Joint Location

Appendix 2 Photos of Joint Conditions

Figure 20 Tape Insert Joint

Appendix 4 Historical Development of Caltrans Concrete Pavement Design

(From Ames Paper Entitled: Concrete Pavement Design and Rehabilitation in California--1985)

- 1912 First Concrete road: 15 ft wide, 4 inches thick, thin bituminous surface coating
- 1920s (mid) Standard Design: 5 inches thick and 18-20 ft wide.
- 1931 Standard Design: 7 in thick center section with outer 2ft tapered to 9in thick, 20 ft wide (to carry 2-way traffic). The outer two feet of the slab (thickened edge) include two ½" square bars parallel to the longitudinal direction for a total of 8 bars per slab, placed adjacent to the interior and exterior edges of the 10 lanes. The standard also included an overlay to widen the existing concrete lanes
- 1940 California's first concrete freeway (Arroyo Secco Parkway) is 6 5/8" center thickness that tapers to 9 inches as the edges. Constructed with three lanes in each direction. Two outside lanes were concrete and inside lane was 6 inches of AC. Concrete placed on subgrade.
- 1946 CTB Trial sections placed to attempt to reduce base erosion.
- 1952 Standard Design: 8" thick, JPCP on road mixed cement treated subgrade or base, 15 ft non skewed joint spacing. Keyways and Longitudinal tie bolts or bars required on longitudinal joints and transverse construction joints to prevent separation and differential settlement.
- 1957 Standard Design Change: The 1952 standard was now only used on roadways with a 10 year design life with a traffic index less than 10. For TI greater than 10 a 9 in thick section was required.
- 1960s (early) slip form pavers used, and plant mix CTB adopted as the standard base for concrete pavement. It was believed that the higher quality base would eliminate pumping and reduce faulting which was becoming more evident on the sections constructed without CTB and also those constructed with the road mixed cement stabilization methods.
- 1960s: A 20 year design life adopted: 8 inch JPCP on 4" CTB on a minimum of 6" ASB. Soon after adoption of the stabilized base design, the use of tie bars for the longitudinal lanes was dropped. They were experiencing longitudinal cracking at the ends of the tie bars.
- 1960's: Joint study with General Motors to change joint spacing from uniform 15 ft non-skewed to 12, 13, 19, and 18 ft skewed on 1:6.
- 1960's: Interest in developing a rational pavement design procedure instead of using the standard structural section approach. Caltrans was looking at the PCA approach which used the plate bearing test for subgrade characterization. A Joint study between PCA and Caltrans to develop a correlation between R-Value test and Plate Bearing test was conducted.
- 1967 PCA design procedure modified and adopted by Caltrans. This new design procedure did not materially change the design thicknesses as they were still consistent with the 1957 standards. The new design procedure did result in an occasional increase in thickness from the 1957 9 in maximum thickness to 10 ¼ inches where heavy truck traffic was predicted.
- 1960s (Late) Caltrans embarked on extensive research program to determining cause of step faulting which was becoming a very big concern for concrete pavement. New design procedures did not solve this issue. Findings as follows:

Appendix 4 Historical Development of Caltrans Concrete Pavement Design

  - Faulting was a result of uneven deposition of eroded CTB and shoulder aggregate base fines under transverse joints as a result of pumping action induced by the presence of free water, slab curling and warping, and heavy wheel loads.
- 1979: In a recognition that the 1967 design procedure was inadequate Caltrans increased the truck lane thickness an arbitrary 0.1 ft to provide better service.
- 1980 experimental installation of edge drains to eliminate pumping and fines erosion under joints.
- 1980s: Research determined the following design deficiencies in the 1967 design procedures:
  - Based on assumption that concrete fails in fatigue while remaining in contact with base materials and subgrade. Fatigue failure under full subgrade support is a text book example that rarely is seen in practice.
  - It did not account for environmental factors such as rainfall, moisture retention in the subgrade, etc.
  - It was very insensitive to projected traffic levels often resulting in difference in thickness of only 0.05 ft.
- 1980s: Changed joint spacing to 12, 15, 13, and 14 ft (13.5 average) to reduce curling and warping caused by temperature and moisture changes.
- 1982: Standard Design sections once again adopted by Caltrans. However, they were verified using the 1981 AASHTO Interim Guide for Design of Pavements. The Goals of the new standards were to:
  - Provide a non-erodible, free-draining structural roadbed cross section the will minimize faulting and resultant cracking.
  - Four non-erodible bases were specified:
    - Lean Concrete Base
    - Asphalt Concrete Base
    - Asphalt-treated Permeable Base
    - Cement Treated Permeable Base
  - Used edge drains
- Need something from 1984 on which describes the discontinuence of edge drains, and what happened from 84 to 95.