NUMBER 7

TECH TOPIC

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PERFORMANCE GRADED (PG) POLYMER MODIFIED ASPHALTS IN CALIFORNIA

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Introduction

In January 2006, when the Performance Graded (PG) system for asphalt cements replaced the Aged Residue (AR) grading system formerly in use, four polymer modified Performance Based Asphalts (PBA) were retained for interim use until they could be replaced by PG polymer modified (PG-PM) grades. In 2006, a Caltrans-Industry task force examined the PBA grades and identified appropriate replacement polymer modified PG grades. **The implementation date for replacing the PBA polymer modified asphalts with PG polymer modified asphalts is January 1, 2007.**

Background

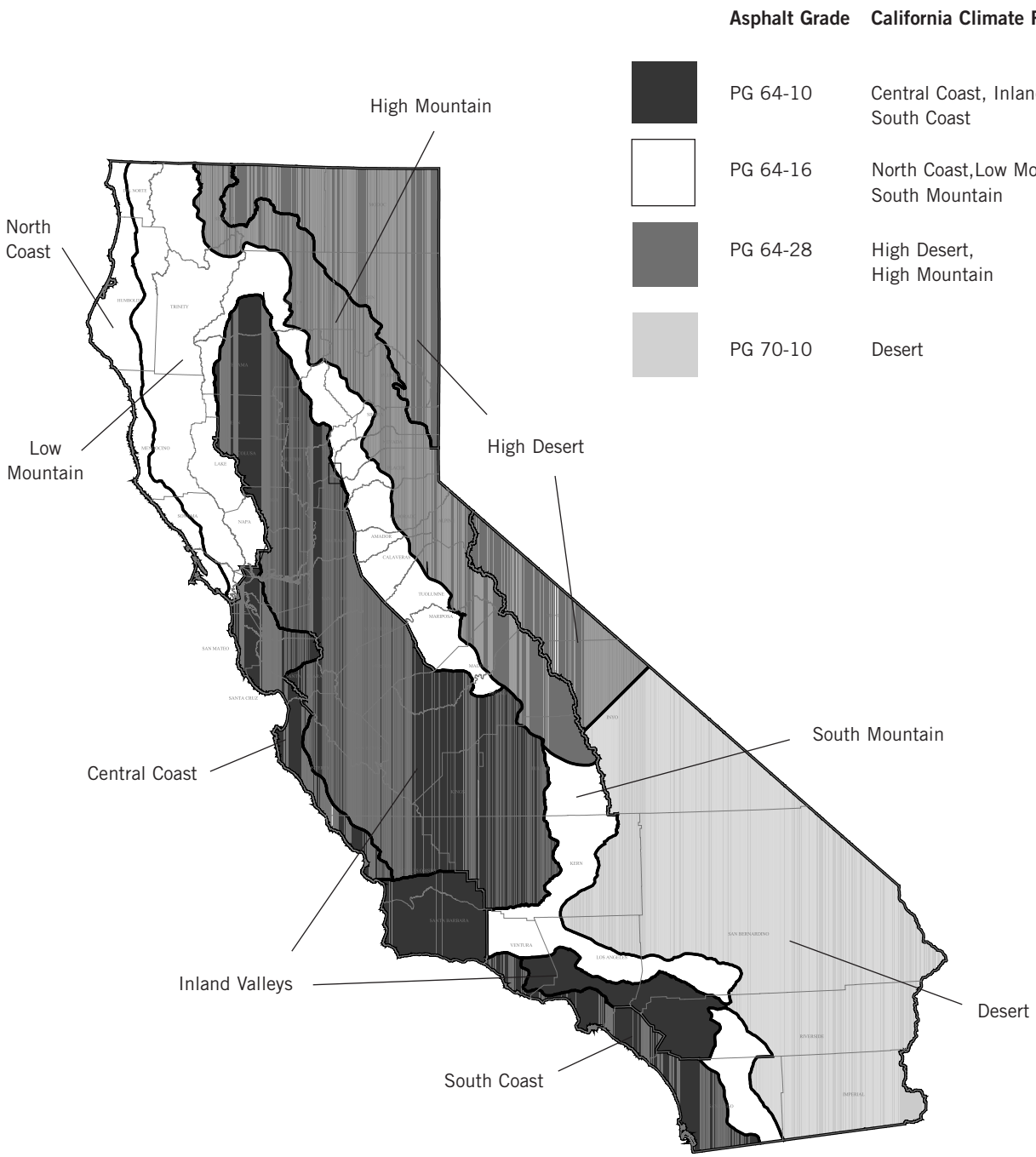
Technical Topics No. 6: Performance Graded (PG) Asphalts in California[1] examined the evolution of asphalt specifications that led to the adoption and implementation of the PG system by the California Department of Transportation (Caltrans) in January 2006.

Caltrans selected four primary PG asphalt grades to cover the various climate regions of California (see Figure 1). These conventional PG asphalts do not require modification, although some suppliers may still find it necessary to treat their asphalt to satisfy specification requirements for the PG 64-28 material. Caltrans also added one additional PG asphalt (PG 58-22) as a base stock in the production of asphalt rubber binder for use in the colder climate regions of California. Specifications for all five PG asphalts are included on the specification sheet at the end of this article.

Polymer modified asphalts are frequently preferred in extreme climate regions such as the High Mountain or Desert regions, and where high traffic or heavy loading conditions exist, such as at intersections, port installations and airfields. The task force examined the four PBA grades which were retained to meet these needs and determined that they could effectively be replaced by three PG polymer modified asphalts. The four polymer modified PBA grades were: PBA 6a, 6a+, 6b, and 7.

FIGURE 1

PG Binder Map for California



On January 1, 2007, these PBA grades will be replaced by three new polymer modified PG grades: PG 58-34PM, PG 64-28PM, and PG 76-22PM.

Replacement Grades

The Caltrans binder selection chart in Table 1 shows the appropriate PG asphalts, conventional and polymer modified, to be used for the various California climate regions and mix types.

PG 64-28PM is the recommended polymer modified asphalt for dense graded mixes in all climate regions in California except the colder climate High Mountain and High Desert regions. For these regions, the preferred polymer modified asphalt for dense graded mixes is PG 58-34PM.

PG 58-34PM is the polymer modified asphalt of choice for open graded mixes placed at lay down temperatures less than 70ºF (21.1ºC) in all climate regions except the Desert region where the selection of binder grade is left to the discretion of the District Materials Engineer.

PG 76-22PM may be specified for dense graded mixes in all climate regions throughout California for special applications. These applications include highly stressed, heavily loaded sections such as highway off ramps, intersections, port loading facilities, and major airfields.

TABLE 1

Caltrans PG Asphalt Binder Grades

Binder / Climactic Region	Conventional Hot Mixed Asphalt				Rubberized Asphalt
	Dense Graded HMA		Open Graded Lay Down Temperature		Base Stock for Gap and Open Graded[d]
	Typical	Special[a]	>70°F	<70°F	
Central Coast, Inland Valleys, South Coast	PG 64-10	PG 70-10 PG 64-28PM	PG 64-10	PG 58-34PM	PG 64-16
North Coast, Low Mountain, South Mountain	PG 64-16	PG 64-28PM	PG 64-16	PG 58-34PM	PG 64-16
High Desert, High Mountain	PG 64-28	PG 58-34PM[b]	PG 64-28	PG 58-34PM	PG 58-22
Desert	PG 70-10	PG 64-28PM	PG 70-10	See Note c	PG 64-16

Notes:

a. PG 76-22PM may be specified for conventional dense graded hot mix asphalt for special conditions in all climactic regions when specifically requested by the District Materials Engineer.
b. PG 64-28PM may be specified when specifically requested by the District Materials Engineer.
c. Consult the District Materials Engineer for appropriate binder grade.
d. Do not use a polymer modified binder as base stock for rubber modified binder.

Specifications

Specifications for the three PG polymer modified asphalts are included on the specification sheet at the end of the article. The Caltrans PG polymer modified asphalt specifications differ from the national AASHTO M320-04 specifications for PG asphalts in the following ways:

- ➜ Caltrans has a solubility requirement of 98.5% minimum on the original binder in its specification, compared to a 99.0% minimum in AASHTO M320-04.
- ➜ The Caltrans specification calls for a 0.60% maximum mass loss from the RTFO test rather than the 1.0% maximum loss in AASHTO M320-04.
- ➜ The Caltrans specification has a minimum elastic recovery requirement and a maximum phase angle requirement from the dynamic shear test on the RTFO aged binder to ensure the presence of an appropriate level of polymer.

Types of Polymers

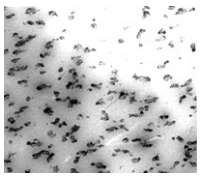
There are several classes of polymers used to modify asphalt[2]. They include plastics, such as polyethylene, polypropylene, and ethylene vinyl acetate (EVA) and elastomers including styrene-butadiene-rubber (SBR), styrene-butadiene-styrene (SBS), natural rubber, and reclaimed tire rubber. Elastomers are the most widely used polymer modifiers of asphalt. Often, combinations of polymers are used to get the desired properties.

Why Polymer Modify?

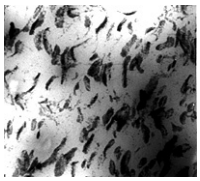
The addition of polymers to asphalt in concentrations of roughly 3% or more significantly alters asphalt behavior and hence asphalt mix behavior[3]. Elastomers are rubbery in nature and tend to form entanglements or networks within the asphalt continuous phase similar to that shown in Figure 2. Plastics, or plastomers, are stiff and tend to form a semi-crystalline structure within the asphalt. In polymer modified asphalts where elastomers are the only modifier, the base asphalt is normally a soft asphalt. The polymer addition increases the viscosity (stiffness) and flexibility of the blend at high and intermediate temperatures, thus improving the rut resistance and fatigue characteristics of the mix while the softer asphalt base and polymer presence provide improved low temperature cracking resistance. The increased viscosity of polymer modified asphalts at high temperatures also results in thicker films on the aggregate particles, causing less "drain down" in open graded mixes and providing better long term durability for all mix types. The effect of polymer modification is illustrated in Figure 3.

FIGURE 2

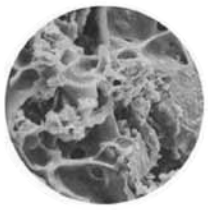
Typical Polymer Structures in Elastomer Modified Asphalts



2% SBS in Asphalt



4% SBS in Asphalt



SBR Modified Asphalt

Left and center images courtesy of FHWA; image on right courtesy of the Asphalt Institute

Manufacturing Processes

The most common method used to manufacture polymer modified asphalts is to preblend the polymer and asphalt at a terminal or refinery. Some systems allow the simple mixing of the polymer into the asphalt in a mixing tank at elevated temperatures, while others require high shear milling of a polymer/asphalt concentrate or some other special mixing operation. A typical SBS blending process is shown schematically in Figure 4.

Construction Issues

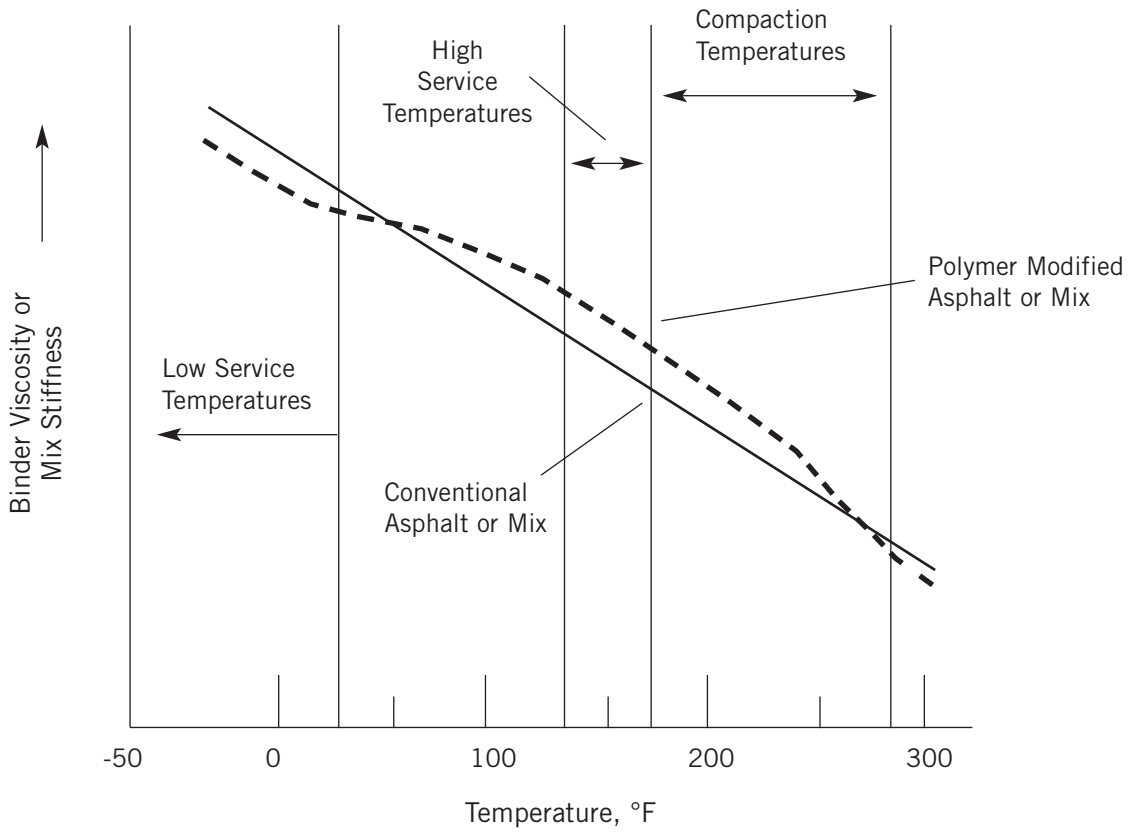
Caltrans will work closely with industry to ease the transition from the PBA grades to the PG polymer modified asphalts. Projects that are awarded in 2006 and extend into 2007 may involve an asphalt binder change. Caltrans will allow the contractor to use the PBA grade specified for the job until the project is completed, even if the project extends beyond the January 1,

2007 implementation date. Alternatively, the contractor will be allowed to switch to the equivalent polymer modified PG asphalt during the project if the PBA asphalt is no longer available from the supplier.

Contractors familiar with the behavior of PBA mixes should find relatively little difficulty in switching from a PBA 6a mix to a mix made with PG 58-34PM asphalt. Similarly, PG 64-28PM mixes are expected to behave much like PBA 6a+ mixes. On the other hand, the highly modified PG 76-22PM asphalt can produce mixes that are difficult to place and compact. Higher mixing and compaction temperatures may be needed with these mixes. Contractors who have not worked with polymer modified mixes in the recent past would be well advised to construct test strips prior to any major jobs to familiarize themselves with mix behavior idiosyncrasies.

FIGURE 3

Effect of Polymer Modification on Asphalt and Asphalt Mix Properties



Adapted from Terrel, R.L. and J.A. Epps, "Using Additives and Modifiers in Hot Mix Asphalt," Quality Improvement Series, QIP114A/89, National Asphalt Pavement Association.

FIGURE 4

SBS Blending System for Asphalt Terminals

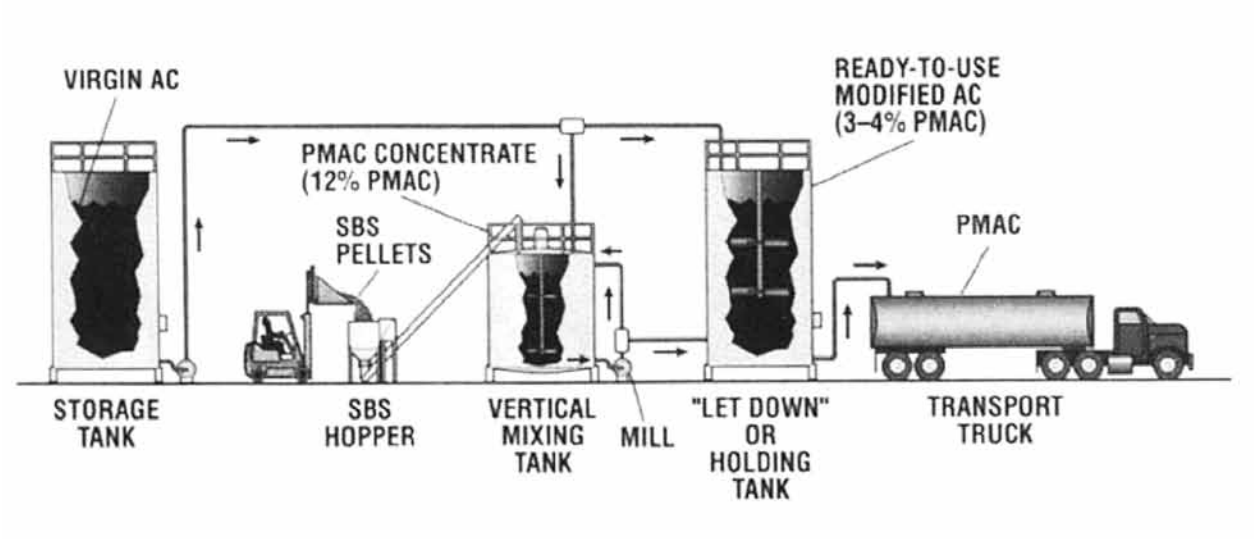


Image courtesy of the Asphalt Institute archives[2]

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References

1 "Performance Graded (PG) Asphalts in California," *Technical Topics No.6,* Technology Transfer Program, Institute of Transportation Studies, University of California Berkeley www.techtransfer.berkeley.edu/techtopics.

2 "Polymer-Modified Asphalt for the Paving Industry," *Information Series IS-200,* Asphalt Institute, 1999.

3 "Quantifying the Effects of PMA," *Information Series IS-215,* Asphalt Institute, 2005.

CALTRANS SPECIFICATIONS FOR PERFORMANCE GRADED ASPHALTS

(effective January 1, 2007)

This information can also be found in Section 92 of the Caltrans Standard Specifications available at http://www.dot.ca.gov/hq/esc/oe/specifications/std_specs

Performance Graded Asphalt Binder

Property	AASHTO Test Method	Specification Grade PG 58-22[a]	PG 64-10	PG 64-16	PG 64-28	PG 70-10
Original Binder						
Flash Point, Min. °C	T48	230	230	230	230	230
Solubility, Min. %[b]	T44	99	99	99	99	99
Viscosity at 135°C,[c] Max., Pa_s	T316	3.0	3.0	3.0	3.0	3.0
Dynamic Shear, Test Temp. at 10 rad/s, °C	T315	58	64	64	64	70
Min. G*/sin(delta), kPa		1.00	1.00	1.00	1.00	1.00
RTFO Test[e], Mass Loss, Max., %	T240	1.00	1.00	1.00	1.00	1.00
RTFO Test Aged Binder						
Dynamic Shear, Test Temp. at 10 rad/s, °C	T315	58	64	64	64	70
Min. G*/sin(delta), kPa		2.20	2.20	2.20	2.20	2.20
Ductility at 25°C Min., cm	T51	75	75	75	75	75
PAV[f] Aging, Temperature, °C	R28	100	100	100	100	110
RTFO Test and PAV Aged Binder						
Dynamic Shear, Test Temp. at 10 rad/s, °C	T315	22[d]	31[d]	28[d]	22[d]	34[d]
Min. G*sin(delta), kPa		5000	5000	5000	5000	5000
Creep Stiffness,	T313					
Test Temperature, °C		-12	0	-6	-18	0
Max. S-value, MPa		300	300	300	300	300
Min. M-value		0.300	0.300	0.300	0.300	0.300

Notes:

a. For use as asphalt rubber base stock for high mountain and high desert area.

b. The Engineer will waive this specification if the supplier is a Quality Supplier as defined by the Department's "Certification Program for Suppliers of Asphalt."

c. The Engineer will waive this specification if the supplier certifies the asphalt binder can be adequately pumped and mixed at temperatures meeting applicable safety standards.

d. Test the sample at 3°C higher if it fails at the specified test temperature. G*sin(delta) shall remain 5000 kPa maximum.

e. "RTFO Test" means the asphaltic residue obtained using the Rolling Thin Film Oven Test, AASHTO Test Method T240 or ASTM Designation: D 2872.

f. "PAV" means Pressurized Aging Vessel.

Performance Graded polymer modified asphalt binder (PG Polymer Modified) shall conform to the following:

Performance Graded Polymer Modified Asphalt Binder[a]

Property	AASHTO Test Method	Specification Grade PG 58-34 PM	PG 64-28 PM	PG 76-22 PM
Original Binder				
Flash Point, Minimum °C	T48	230	230	230
Solubility, Minimum %[b]	T44[c]	98.5	98.5	98.5
Viscosity at 135°C,[d] Maximum, Pa_s	T316	3.0	3.0	3.0
Dynamic Shear, Test Temp. at 10 rad/s, °C	T315	58	64	76
Minimum G*/sin(delta), kPa		1.00	1.00	1.00
RTFO Test , Mass Loss, Maximum, %	T240	0.60	0.60	0.60
RTFO Test Aged Binder				
Dynamic Shear, Test Temp. at 10 rad/s, °C	T315	58	64	76
Minimum G*/sin(delta), kPa		2.20	2.20	2.20
Dynamic Shear, Test Temp. at 10 rad/s, °C	T315	Note e	Note e	Note e
Maximum (delta), %		80	80	80
Elastic Recovery[f], Test Temp., °C	T301	25	25	25
Minimum recovery, %		75	75	65
PAV[g] Aging, Temperature, °C	R28	100	100	110
RTFO Test and PAV Aged Binder				
Dynamic Shear, Test Temp. at 10 rad/s, °C	T315	16	22	31
Maximum G*sin(delta), kPa		5000	5000	5000
Creep Stiffness, Test Temperature, °C	T313	-24	-18	-12
Maximum S-value, MPa		300	300	300
Minimum M-value		0.300	0.300	0.300

Notes:

a. Performance Graded Polymer Modified Asphalt Binder (PG Polymer Modified) will not be modified using acid modification.

b. The Engineer will waive this specification if the supplier is a Quality Supplier as defined by the Department's "Certification Program for Suppliers of Asphalt."

c. ASTM D5546 is allowed in lieu of AASHTO T44

d. The Engineer will waive this specification if the supplier certifies the asphalt binder can be adequately pumped and mixed at temperatures meeting applicable safety standards.

e. Test temperature is the "temperature at which G*/sin(delta) equals 2.2 kPa". A graph of log G*/sin(delta) plotted against temperature can be used to determine the test "temperature at which G*/sin(delta) is 2.2 kPa". A graph of (delta) versus temperature can also be used to determine delta at "temperature where G*/sin(delta) is 2.2 kPa". Direct measurement of (delta) at the "temperature at which G*/sin(delta) is 2.2 kPa" is also acceptable.

f. Test can be performed without force ductility clamp.

g. "PAV" means Pressurized Aging Vessel.