



2016 CRUMB RUBBER REPORT

Cost Differential Analysis Between Asphalt Containing Crumb Rubber and Conventional Asphalt

Public Resources Code Section 42703

Prepared by



This page blank intentionally.

CONTENTS

Executive Summary	1
Crumb Rubber Usage Analysis and Results	3
Table 1 2016 Data Analysis Results Crumb Rubber Usage.....	4
Table 2 2016 Data Analysis Results CRM Usage per Metric Ton by Pavement Project Type For Asphalt Containing CRM Versus Conventional Asphalt	6
Cost Comparison Analysis and Results	8
Table 3 2016 Data Analysis Results Initial Cost Comparison per Metric Ton by Pavement Project Type for Asphalt Containing Crumb Rubber Versus Conventional Asphalt.....	10
Findings and Recommendations	11
Appendix: Public Resources Code Section 42703.....	12

This page blank intentionally.

Executive Summary

Assembly Bill 338 (Levine, Chapter 709, Statutes of 2005), an act to add Section 42703 to the Public Resources Code, relating to recycling, was chaptered on October 7, 2005. The intent of this legislation was to require the California Department of Transportation (Caltrans) to use more asphalt containing crumb rubber when it is cost-effective compared with conventional asphalt. The ultimate goal of this legislation is to increase the recycling of the more than 40 million reusable and waste tires generated each year in California and thereby, reduce the amount of tires placed in landfills and scrap tire piles. In calendar year 2016, Caltrans' projects that used asphalt containing crumb rubber diverted more than 4.7 million waste tires from landfills and tire stockpiles.

Public Resources Code [Division 30, Part 3, Chapter 14, Article 1] Section 42703, requires Caltrans to meet specified usage amounts of crumb rubber modifier (CRM) in asphalt pavement and requires the Secretary of the California State Transportation Agency to annually "prepare an analysis comparing the cost differential between asphalt containing crumb rubber and conventional asphalt" paving material. Caltrans met these requirements in calendar year 2016.

This report addresses Public Resources Code Section 42703(a)(3), 42703(b)(3), 42703(c)(1)(A), (B), and (C), and 42703(c)(2) (see Appendix for the full text of Public Resources Code Section 42703). The four major pavement project categories used in the analysis for this report were: Pavement Preservation (Maintenance), Rehabilitation, Capital Preventive Maintenance (CAPM), and New Capacity/Safety/Temporary Detours.

Public Resources Code Section 42703(a)(3) requires that "on and after January 1, 2013, the Department of Transportation shall use, on an annual average, not less than 11.58 pounds of CRM per metric ton of the total amount of asphalt paving materials used," which is a calculated target percentage of 35 percent. Of the 4.3 million metric tons of paving asphalt Caltrans used in calendar year 2016, 1.7 million metric tons contained crumb rubber, an average of 39.8 percent. Caltrans also used an average of 60.9 million pounds of CRM in rubberized asphalt concrete, equating to 14.0 pounds of CRM per metric ton. (See Table 1 and Chart on page 4.)

Caltrans counted the use of only rubberized asphalt concrete to comply with the requirements of Public Resources Code Section 42703(b)(3), which mandates that "on and after January 1, 2015, the Department of Transportation may use any material meeting the definition of asphalt containing crumb rubber, with respect to product type or specification, to comply with the requirements of subdivision (a) [of Section 42703]."

Caltrans is still in the process of collecting data from three annual pavement condition surveys of asphalt concrete and rubberized asphalt concrete to calculate and determine the lifespan and duration of asphalt concrete, as required by Public Resources Code Section 42073(c)(1)(A). The third annual pavement condition survey will be collected in 2018. The results of these surveys will be analyzed and reported in the 2018 Crumb Rubber Report.

In order to perform the analysis required by Public Resources Code Section 42703(c)(1)(C), the material lifespan and maintenance costs for both asphalt containing crumb rubber and conventional asphalt were assumed equal. The initial cost per metric ton of asphalt containing crumb rubber varies depending on the project category. For all project categories, the initial cost of asphalt containing crumb rubber was more than the cost of conventional asphalt – for Pavement Preservation (Maintenance) projects, it was about 8.5 percent more; for Rehabilitation projects, it was about 24.5 percent more; for CAPM projects, it was about 18.2 percent more; and for New Capacity/Safety/Temporary Detours projects, it was 23.2 percent more. (See Table 3 on page 9.)

In 2017, Caltrans updated the *2015 Revised Standard Specifications* to include CRM reporting requirements where contractors work with resident engineers to document and report on the weight, in pounds, of CRM used in contracts. The *Construction Manual* will be updated to reflect the CRM reporting requirement change in the *2015 Revised Standard Specifications*. In the meantime, Construction Policy Bulletin (CPB 17-2) effective 7-15-17 has been issued to outline these requirements. Also, the Pavement and Materials Partnering Committee, formerly Rock Products Committee, has a current project exploring the opportunity to require a small amount of CRM to be incorporated into asphalt binders used in all highway asphalt paving materials. The anticipated completion date for this project is June 30, 2019.

Caltrans' research has shown that asphalt pavement containing crumb rubber overlays is cost effective when used to resist reflective cracking. Caltrans will continue to use sound engineering judgment to determine when and where asphalt containing crumb rubber shall be placed.

Crumb Rubber Usage Analysis and Results

Public Resource Code Section 42703(a)(3) requires that “on and after January 1, 2013, the Department of Transportation shall use, on an annual average, not less than 11.58 pounds of CRM per metric ton of the total amount of asphalt paving materials used.”

Caltrans’ Division of Construction’s Contract Administration System’s Progress Payment Database provided the pavement projects’ costs and the total tonnage placed of asphalt containing crumb rubber and conventional asphalt during calendar year 2016. The method used to determine the amount of CRM per metric ton of asphalt placed required the following assumptions:

1. CRM asphalt binder contains between 18 to 22 percent CRM for rubberized hot-mix asphalt; calculations were based on a value of 20 percent.
2. CRM asphalt binder contains between 8 to 12 percent CRM for hot-mix asphalt with terminal blend binder; calculations were based on a value of 10 percent.
3. Asphalt containing crumb rubber has the following CRM asphalt binder content ranges:
 - Gap-graded rubberized hot-mix asphalt contains between 7.5 to 9 percent CRM asphalt binder, based on average field mix designs; a value of 8 percent was used for calculations.
 - Open-graded rubberized hot-mix asphalt contains between 7.5 to 10 percent CRM asphalt binder, based on average field mix designs; a value of 8 percent was used for calculations.
 - Hot-mix asphalt terminal blend contains between 5.2 to 6 percent CRM asphalt binder, based on average field mix designs; a value of 5.2 percent was used for calculations.

To comply with Public Resources Code Section 42703(a)(3), the target percentage, which equated to 35 percent, was calculated based on Caltrans’ use of CRM per metric ton of the total amount of asphalt paving materials used, and the annual average mandate of 11.58 pounds (for 2013 and beyond).

The results of the crumb rubber usage analysis are shown in Table 1 and in the Chart on the next page.

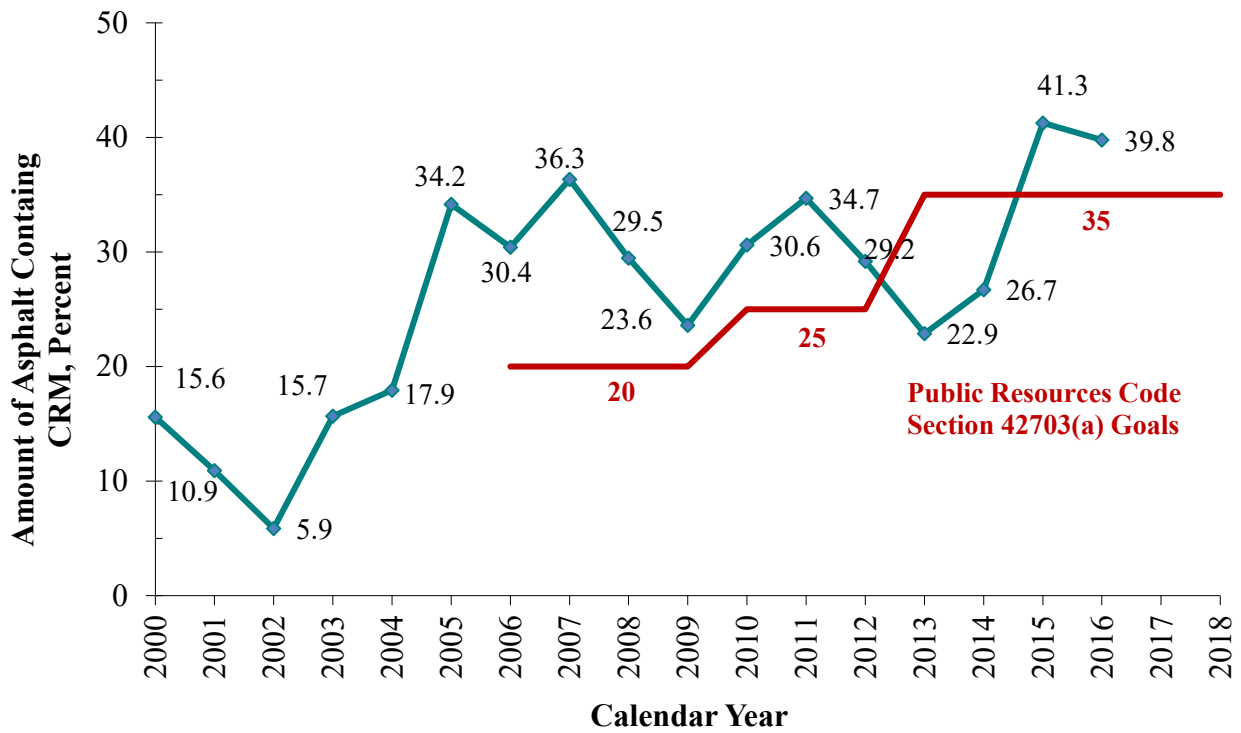
TABLE 1

2016 DATA ANALYSIS RESULTS
CRUMB RUBBER USAGE

Quantity of Asphalt Placed (Metric Tons)			Asphalt Containing Crumb Rubber to Total Asphalt Paving (Percent)	Crumb Rubber Placed (Average Pounds)	Pounds of CRM per Metric Ton of Total Asphalt Placed (Calculated)
Total Asphalt	Conventional Asphalt	Asphalt Containing Crumb Rubber			
4,341,069	2,614,771	1,726,299	39.8	60,892,762	14.0

Data compiled for this analysis was based on 705 projects in construction with paving in calendar year 2016.

**PERCENTAGE OF ASPHALT CONTAINING CRM
USED BY CALTRANS**



In calendar year 2016, Caltrans diverted more than 4.7 million waste tires from landfills and tire stockpiles, due to projects using asphalt containing crumb rubber. The projects used 4.3 million metric tons of paving asphalt and of that amount, 1.7 million metric tons contained crumb rubber, which is an average of 39.8 percent of the total paving asphalt. Caltrans used an average of 60.9 million pounds of CRM in rubberized asphalt concrete, equating to 14.0 pounds of CRM per metric ton.

The data below in Table 2 show a breakdown of the results for CRM usage per metric ton for asphalt containing CRM versus conventional asphalt by the four major pavement project categories used in the analysis for this report, which were: Pavement Preservation (Maintenance), Rehabilitation, Capital Preventive Maintenance (CAPM), and New Capacity/Safety/Temporary Detours. Descriptions of these categories can be found below under Cost Comparison Analysis and Results.

TABLE 2				
2016 DATA ANALYSIS RESULTS				
CRM USAGE PER METRIC TON BY PAVEMENT PROJECT TYPE				
FOR ASPHALT CONTAINING CRM VERSUS CONVENTIONAL ASPHALT				
Pavement Category	Total Asphalt Used	Conventional Asphalt	Asphalt Containing CRM	Percent of Asphalt Containing CRM
Pavement Preservation (Maintenance)	1,275,528	651,410	624,118	48.9
Rehabilitation	451,765	299,505	152,261	33.7
Capital Preventive Maintenance (CAPM)	1,445,570	595,530	850,041	58.8
New Capacity/Safety/Temp. Detours	1,168,206	1,068,326	99,879	8.5
TOTAL	4,341,069	2,614,771	1,726,299	39.8

The total percentage of asphalt containing CRM slightly decreased from 41.3 percent to 39.8 percent from 2015 to 2016. This decrease is due to a decrease in the amount of CRM that was used in each of the four major pavement project categories: Preservation (-3.1%), Rehabilitation (-10.7%), Capital Preventive Maintenance (-4.1%), and New Capacity/Safety/Temporary Detours (-32.8%). However, the amount of tires diverted from landfills and tire stockpiles increased by 0.1 million from 2015.

Public Resources Code Section 42703(b)(3) mandates that “on and after January 1, 2015, the Department of Transportation may use any material meeting the definition of asphalt containing crumb rubber, with respect to product type or specification, to comply with the requirements of subdivision (a) [of Section 42703].” In calendar year 2016, Caltrans exclusively used rubberized asphalt concrete to comply with the requirements of Public Resources Code Section 42703(b)(3).

In 2017, Caltrans updated the *2015 Revised Standard Specifications* to include CRM reporting requirements. Contractors report on the weight, in pounds, of CRM used in contracts on the “Crumb Rubber Usage Report” form CEM-4410. The contractor submits the form monthly to the construction resident engineer and e-mail account at <CRM@dot.ca.gov> for contracts having items of work containing CRM. The resident engineer verifies and signs the form. The *Construction Manual* will be updated to reflect the CRM reporting requirement change in the

2015 Revised Standard Specifications. In the meantime, Construction Policy Bulletin (CPB 17-2) effective 7-15-17 has been issued to outline these requirements.

In addition, the Division of Maintenance and the Division of Design will review all asphalt pavement projects for use of asphalt containing crumb rubber during a 3-year period so that such usage can be predicted prior to project construction. Caltrans expects to report this in the 2017 Crumb Rubber Report.

Asphalt pavement guidelines, such as the *Highway Design Manual*, were updated in 2017 to allow use of conventional asphalt by exception only. During construction, exceptions to using asphalt containing crumb rubber may be considered because of things such as the availability of asphalt concrete, constructability, environmental factors, and cost. Exceptions may cover the following situations:

- When CRM project quantities are less than 1,000 metric tons, or stage construction operations require less than 1,000 metric tons per stage.
- When the temperature is below 45 degrees Fahrenheit.
- Where the roadway is above 3,000 feet in elevation.
- When placed as a concrete pavement asphalt base.
- When placed as a bond breaker between the asphalt and concrete pavement layers.

The Asphalt Task Group of the Pavement and Materials Partnering Committee is working on a project exploring the opportunity to require the incorporation of small amounts of crumb rubber in asphalt binder to be used in all highway asphalt paving materials. The scheduled completion date for this project was June 30, 2018. However, due to the need to gather additional data and perform additional testing this will now expected to be delayed by a year.

Cost Comparison Analysis and Results

Public Resources Code Section 42703(c)(1) requires the Secretary of the California State Transportation Agency, “on or before January 1 of each year, prepare an analysis comparing the cost differential between asphalt containing crumb rubber and conventional asphalt.” The cost comparison analysis for calendar year 2016 was segregated by the four major pavement project categories: Pavement Preservation (Maintenance), Rehabilitation, Capital Preventive Maintenance (CAPM), and New Capacity/Safety/Temporary Detours (such as lane additions, new road alignments, and safety and landscape projects).

Caltrans’ Division of Construction’s Contract Administration System’s Progress Payment Database was used to obtain the costs of various pavement projects and total tonnage of materials.

Four major assumptions were necessary before any cost comparisons could be made:

1. Cost per metric ton for asphalt material was calculated based on the tonnage and bid item cost of the asphalt material.
2. Cost comparisons were completed for the following categories of projects:
 - *Pavement Preservation (Maintenance)*. Overlay strategies, compared and placed at the same one-inch minimum thickness under the maintenance preservation program.
 - *Rehabilitation*. Pavement rehabilitation projects funded from the State Highway Operation and Protection Program (SHOPP).
 - *Capital Preventive Maintenance (CAPM)*. CAPM strategies are thinner than rehabilitation strategies and are usually double the thickness of pavement preservation (maintenance) treatments funded from the SHOPP.
 - *New Capacity/Safety/Temporary Detours*. All other program projects not listed in the above categories (such as safety, landscape, State Transportation Improvement Program, and protective betterment projects).

These first two assumptions were necessary because Caltrans has many different types of projects such as roadway rehabilitation, roadside, safety, and drainage, which contain small amounts of asphalt that would make a cost-per-metric-ton analysis meaningless. Similar types of strategies need to be compared for an accurate cost comparison between asphalt containing crumb rubber and conventional asphalt.

3. Rehabilitation strategies with asphalt containing crumb rubber and conventional asphalt lifespans were considered the same.

This assumption was necessary because pavement lifespan data, which can be used to predict pavement lifecycles, is still under development in Pavem. It is anticipated these pavement lifecycles will be refined in 2018. For this report, expected lifespans were assumed the same for asphalt containing crumb rubber and conventional asphalt. The asphalt lifespan was assumed to be three years to five years for Pavement Preservation (Maintenance) projects, ten years for Rehabilitation projects, five years to seven years for CAPM projects, and twenty years for New Construction projects. However, after Caltrans completes data collection from three annual pavement condition surveys of the State Highway System, the lifespan and duration of asphalt materials can be calculated and will be provided, as required by Public Resources Code Section 42073(c)(1)(A). The results of these surveys will be analyzed and reported in the 2017 Crumb Rubber Report.

4. Maintenance costs for asphalt containing crumb rubber and conventional asphalt were considered the same and did not affect the cost comparison.

This assumption was necessary because Caltrans' Integrated Maintenance Management System does not segregate pavement maintenance costs for asphalt containing crumb rubber and conventional asphalt material from other pavement work. Caltrans' ability to segregate and calculate maintenance costs for asphalt containing crumb rubber or conventional asphalt locations is difficult to quantify accurately. Consequently, maintenance costs were not included in the analysis, and were assumed the same, for asphalt containing crumb rubber and conventional asphalt.

These four listed assumptions and the progress payment data from the Division of Construction's Contract Administration System were used for the cost comparison analysis. The results shown in Table 3 on the next page, are segregated by the four major pavement project categories.

<p style="text-align: center;">TABLE 3</p> <p style="text-align: center;">2016 DATA ANALYSIS RESULTS</p> <p style="text-align: center;">INITIAL COST COMPARISON PER METRIC TON BY PAVEMENT PROJECT TYPE</p> <p style="text-align: center;">FOR ASPHALT CONTAINING CRUMB RUBBER VERSUS CONVENTIONAL</p> <p style="text-align: center;">ASPHALT</p>				
Type of Asphalt	Pavement Preservation (Maintenance)	Rehabilitation	Capital Preventative Maintenance (CAPM)	New Capacity/Safety/Temporary Detours
Asphalt containing crumb rubber	\$97.27	\$98.39	\$92.72	\$99.91
Conventional asphalt	\$89.68	\$79.04	\$78.46	\$81.08

For all four project categories, the initial cost of asphalt containing crumb rubber was more than the cost of conventional asphalt:

- *Pavement Preservation (Maintenance)* projects had a cost difference of \$7.59 between the two types of asphalt, which equated to about 8.5 percent more for the cost of asphalt containing crumb rubber.
- *Rehabilitation* projects had a cost difference of \$19.35 between the two types of asphalt, which equated to about 24.5 percent more for the cost of asphalt containing crumb rubber.
- *CAPM* projects had a cost difference of \$14.26 between the two types of asphalt, which equated to about 18.2 percent more for the cost of asphalt containing crumb rubber.
- *New Capacity/Safety/Temporary Detours* projects had a cost difference of \$18.83 between the two types of asphalt, which equated to about 23.2 percent more for the cost of asphalt containing crumb rubber.

While asphalt pavement containing crumb rubber does initially cost more per metric ton than conventional asphalt pavement for each project category, Caltrans' research has shown that asphalt containing crumb rubber resists reflective cracking better than conventional asphalt pavement. Caltrans will continue to use sound engineering judgment to determine when and where asphalt containing crumb rubber shall be placed.

Findings and Recommendations

In calendar year 2016:

1. Caltrans used an average of 14.03 pounds of CRM per metric ton of total asphalt paving materials, exceeding the Public Resources Code Section 42703(a)(3) requirement of 11.58 pounds of CRM per metric ton of total asphalt paving material used. Caltrans' usage of asphalt containing crumb rubber was 39.8 percent of the total paving asphalt used.
2. Caltrans used rubberized asphalt concrete exclusively to comply with the requirements of Public Resources Code Section 42703(b)(3), which states that "on and after January 1, 2015, the Department of Transportation may use any material meeting the definition of asphalt containing crumb rubber, with respect to product type or specification, to comply with the requirements of subdivision (a) [of Section 42703]."
3. The initial cost per metric ton of asphalt containing crumb rubber varies between 8.5 percent and 24.5 percent more than the cost of conventional asphalt, depending on the project category. Caltrans' research has shown that asphalt pavement containing crumb rubber overlays are cost-effective when used to resist reflective cracking. Caltrans will continue to use sound engineering judgment to determine when and where asphalt containing crumb rubber shall be placed.
4. Caltrans' projects using asphalt containing crumb rubber diverted more than 4.7 million waste tires from landfills and tire stockpiles during calendar year 2016. This is 0.1 million higher than what was diverted during calendar year 2015. Information about additional waste tire applications used by Caltrans is available on the Internet at <<http://www.dot.ca.gov/hq/oppd/rescons/sb876.htm>>.
5. Caltrans' Division of Maintenance and Division of Design will review all asphalt pavement projects for use of asphalt containing crumb rubber during a 3-year period so that such usage can be predicted prior to project construction. Asphalt pavement guidelines, such as the *Highway Design Manual*, was updated in 2017 to allow the use of conventional asphalt by exception only. During construction, exceptions to using asphalt containing crumb rubber may be considered because of such things as the availability of asphalt concrete, constructability, environmental factors, and cost.

Appendix: Public Resources Code Section 42703

42703. (a) Except as provided in subdivision (d), the Department of Transportation shall require the use of crumb rubber in lieu of other materials at the following levels for state highway construction or repair projects that use asphalt as a construction material:

- (1) On and after January 1, 2007, the Department of Transportation shall use, on an annual average, not less than 6.62 pounds of CRM per metric ton of the total amount of asphalt paving materials used.
- (2) On and after January 1, 2010, the Department of Transportation shall use, on an annual average, not less than 8.27 pounds of CRM per metric ton of the total amount of asphalt paving materials used.
- (3) On and after January 1, 2013, the Department of Transportation shall use, on an annual average, not less than 11.58 pounds of CRM per metric ton of the total amount of asphalt paving materials used.

(b) (1) The annual average use of crumb rubber required in subdivision (a) shall be achieved on a statewide basis and shall not require the use of asphalt containing crumb rubber in each individual project or in a place where it is not feasible to use that material.

- (2) On and after January 1, 2007, and before January 1, 2015, not less than 50 percent of the asphalt pavement used to comply with the requirements of subdivision (a) shall be rubberized asphalt concrete.
- (3) On and after January 1, 2015, the Department of Transportation may use any material meeting the definition of asphalt containing crumb rubber, with respect to product type or specification, to comply with the requirements of subdivision (a).

(c) (1) The Secretary Transportation shall, on or before January 1 of each year, prepare an analysis comparing the cost differential between asphalt containing crumb rubber and conventional asphalt. The analysis shall include the cost of the quantity of asphalt product needed per lane mile paved and, at a minimum, shall include all of the following:

- (A) The lifespan and duration of the asphalt materials.
- (B) The maintenance cost of the asphalt materials and other potential cost savings to the department, including, but not limited to, reduced soundwall construction costs resulting from noise reduction qualities of rubberized asphalt concrete.
- (C) The difference between each type or specification of asphalt containing crumb rubber, considering the cost-effectiveness of each type or specification separately in comparison to the cost-effectiveness of conventional asphalt paving materials.

- (2) Notwithstanding subdivision (a), if, after completing the analysis required by paragraph (1), the secretary determines that the cost of asphalt containing crumb rubber exceeds the cost of conventional asphalt, the Department of Transportation shall continue to meet the requirement specified in paragraph (1) of subdivision (a), and shall not implement the requirement specified in paragraph (2) of subdivision (a). If the secretary determines, pursuant to an analysis prepared pursuant to paragraph (1), that the cost of asphalt containing crumb rubber does not exceed the cost of conventional asphalt, the Department of Transportation shall implement paragraph (2) of subdivision (a) within one year of that determination, but not before January 1, 2010.
- (3) Notwithstanding subdivision (a), if the Department of Transportation delays the implementation of paragraph (2) of subdivision (a), the Department of Transportation shall not implement the requirement of paragraph (3) of subdivision (a) until three years after the date the department implements paragraph (2) of subdivision (a).
- (d) For the purposes of complying with the requirements of subdivision (a), only crumb rubber manufactured in the United States that is derived from waste tires taken from vehicles owned and operated in the United States may be used.
- (e) The Department of Transportation and the board shall develop procedures for using crumb rubber and other derived tire products in other projects.
- (f) The Department of Transportation shall notify and confer with the East Bay Municipal Utility District before using asphalt containing crumb rubber on a state highway construction or repair project that overlays district infrastructure.
- (g) For purposes of this section the following definitions shall apply:
- (1) "Asphalt containing crumb rubber" means any asphalt pavement construction, rehabilitation, or maintenance material that contains reclaimed tire rubber and that is specified for use by the Department of Transportation.
 - (2) "Crumb rubber" or "CRM" has the same meaning as defined in Section 42801.7.
 - (3) "Rubberized asphalt concrete" or "RAC" means a paving material that uses an asphalt rubber binder containing an amount of reclaimed tire rubber that is 15 percent or more by weight of the total blend, and that meets other specifications for both the physical properties of asphalt rubber and the application of asphalt rubber, as defined in the American Society for Testing and Materials (ASTM) Standard Specification for Asphalt-Rubber Binder.

(Amended by Stats. 2013, Ch. 352, Sec. 491. (AB 1317) Effective September 26, 2013. Operative July 1, 2013, by Sec. 543 of Ch. 352.)