



**Revised Final Pavement Recommendation Memorandum
Chinquapin Intersection, Glacier Point Road and
Badger Pass Ski Area
Yosemite National Park
Project No. CA PRA-YOSE 15(1)
Mariposa County, California**

Submitted to:

**Federal Highway Administration
Central Federal Lands Highway Division
Denver, Colorado**

Submitted by:

**AMEC Earth & Environmental, Inc.
Tempe, Arizona**

**April 15, 2008
AMEC Job No. 6-117-008002**



April 15, 2008
AMEC Job No. 6-117-008002

Jacobs Civil, Inc.
875 West Elliot Road
Tempe, Arizona 85283

Attn: Berwyn Wilbrink, P.E.

**Re: Revised Final Pavement Recommendation Memorandum
Chinquapin Intersection, Glacier Point Road
and Badger Pass Ski Area
Yosemite National Park
Project No. CA PRA-YOSE 15(1)
Mariposa County, California**

The AMEC Earth & Environmental, Inc. Revised Final Materials Pavement Recommendation Memorandum for the above-referenced project is herewith submitted. The report incorporates comments received from Central Federal Lands Highway Division (CFLHD), dated November 9, 2007 and also those received on a conference call among AMEC, Jacobs and CFLHD on December, 17, 2007. This report also replaces the pavement report dated January 10, 2008 to include a missing pavement thickness table.

Should you have any questions concerning the recommendations presented in this report, please do not hesitate in contacting us.

Respectfully submitted,

AMEC Earth & Environmental, Inc.

Tony J. Freiman, P.E.
Senior Engineer

Reviewed by:

Lawrence A. Hansen, Ph.D., P.E.
Principal Geotechnical Engineer



c: Addressee (6)

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Federal Highway Administration
 Revised Final Pavement Recommendation Memorandum
 Chinquapin Intersection, Glacier Point Road
 and Badger Pass Ski Area
 Yosemite National Park
 Project No. CA PRA-YOSE 15(1)
 Mariposa County, California
 AMEC Job No. 6-117-008002
 April 15, 2008

MATERIALS DESIGN REPORT

**RE: Yosemite National Park
 Chinquapin Intersection, Glacier Point Road & Badger Pass Ski Area
 Project No. CA PRA-YOSE 15(1)
 Mariposa County, California**

MEMORANDUM TYPE: FINAL

SECTION I - PAVEMENT STRUCTURE

ITEM 1 - Structural Thickness (in inches)

	Pulverize Existing AC	PCCP	AC	AB	Pulverized AC	Total Thickness
Wawona Road Sta. 14+00 to 30+50	Yes	---	4.0	---	7.0	11.0
Glacier Point Road Sta. 0+98.1 to 5+00	---	---	4.0	9.0	---	13.0
Glacier Point Road Sta. 5+00 to 268+08.2	Yes	---	3.0	---	8.0	11.0
Badger Pass Ski Area Access Road Sta. 64+67 to 69+98	Yes	---	4.0	9.0	---	13.0
Badger Pass Ski Area Parking Lot	Yes	---	3.0	---	7.0	10.0
Badger Pass Ski Area Bus Pads	---	6.0	---	4.0		10.0

SECTION II - SUBGRADE, SUBBASE AND BASES

ITEM 1 – Road Reconditioning

The existing asphaltic concrete will be pulverized and mixed with the existing base materials to the depth and width shown in the plans.

The Standard Specification 303 should be modified as follows in the Special Contract Requirements:



Federal Highway Administration
Revised Final Pavement Recommendation Memorandum
Chinquapin Intersection, Glacier Point Road
and Badger Pass Ski Area
Yosemite National Park
Project No. CA PRA-YOSE 15(1)
Mariposa County, California
AMEC Job No. 6-117-008002
April 15, 2008

303.02 Add the following:

Crushed aggregate 703.06

Construction Requirements

303.08 Pulverizing. Delete the text and substitute the following:

Pulverize the existing asphalt pavement and/or base to the width and depth shown in the plans with an approved rotary milling machine to meet the following size requirements according to AASHTO T27:

Sieve Designation	Percent Passing
1 inch	100
¾ inch	85 – 100

Place and compact the pulverized material according to Subsection 301.05. Compact each layer to at least 95 percent of maximum density. Determine the in place density and moisture content according to AASHTO T310 or ASTM D2950.

Remove and dispose of unsuitable material prior to pulverizing as directed by the CO. Replace unsuitable material with minor crushed aggregate. Perform work according to Section 308.

Clean the compacted surface of all loose material, dirt, or other deleterious substances by approved methods. Correct surface irregularities by scarifying the defective area and reworking the pulverized material. Finish the pulverized surface according to Subsection 301.06.

ITEM 2 – Minor Crushed Aggregate

The Aggregate Base will be Grading Designation D, and will be as specified in Section 703.05 of the Standard Specifications. Placement of the Aggregate Base will be in accordance with Section 308 of the Standard Specifications.

The Standard Specification 308 should be modified as follows in the Special Contract Requirements:



Federal Highway Administration
 Revised Final Pavement Recommendation Memorandum
 Chinquapin Intersection, Glacier Point Road
 and Badger Pass Ski Area
 Yosemite National Park
 Project No. CA PRA-YOSE 15(1)
 Mariposa County, California
 AMEC Job No. 6-117-008002
 April 15, 2008

308.06 Acceptance Delete the second paragraph and substitute the following:

Construction of roadway aggregate courses will be evaluated under Subsection 106.02 and 106.04. Method 2 compaction will be evaluated under Section 106.04. Sample material from the windrow or roadbed after processing but prior to compaction at the frequency shown in Table 308-1. Submit samples to the CO for verification. Materials that do not meet the approved certification will be considered unacceptable.

Table 308-1 Sampling and Testing Requirements. Delete Table 308-1 and substitute the following:

**Table 308-1
 Sampling and Testing Requirements**

Material or Product	Type of Acceptance (Subsection)	Property or Characteristic	Test Methods or Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Crushed aggregate (1)	Measured and tested for conformance (106.04)	Moisture-Density	AASHTO T180 method D ⁽³⁾	1 for each aggregate supplied.	Production output or stockpile.	---	Before using in work
		Gradation ⁽²⁾	AASHTO T11 and T27	1 for each 1000 t.	From the windrow or roadbed after processing.	---	Before placing next layer
		In-place density and moisture content	AASHTO T310 or other approved procedures	1 for each 1000 t.	In-place completed compaction layer.	---	Before placing next layer

⁽¹⁾ Sampling and testing required for roadway aggregate.

⁽²⁾ Use only sieves indicated for the specified gradation.

⁽³⁾ Minimum of 5 points per Proctor.

For estimating purposes the aggregate base density is 139 pounds per cubic foot and the haul distance is 55 miles.

ITEM 3 – Subexcavation

Material will be excavated below the subgrade elevation in the areas designated in the plans or as directed by the CO. The subexcavation will be as specified in Section 204 of the Standard Specifications.



Federal Highway Administration
Revised Final Pavement Recommendation Memorandum
Chinquapin Intersection, Glacier Point Road
and Badger Pass Ski Area
Yosemite National Park
Project No. CA PRA-YOSE 15(1)
Mariposa County, California
AMEC Job No. 6-117-008002
April 15, 2008

SECTION III - SURFACE TREATMENTS AND PAVEMENTS

ITEM 1 – Hot Asphalt Concrete Pavement

The asphaltic concrete will be as specified in Section 402 of the Standard Specification.

For estimating purposes, the unit weight of the bituminous mix is 150 pounds per cubic foot, the asphalt content is 5.5 percent, and the haul distance is 55 miles.

The Standard Specification 402 should be modified as follows in the Special Contract Requirements:

402.01 Delete the third paragraph and substitute the following:

A minimum of one percent lime is required in the hot asphalt concrete mixture.

Pavement smoothness is type II
Asphalt binder grade is PG 64-28

Construction Requirements

402.03 Composition of Mix (Job-Mix Formula). Delete the first paragraph and substitute the following:

Furnish mixes of aggregate, asphalt binder, recycled asphalt pavement, and additives that meet the applicable aggregate gradation in Table 703-4 and design parameters (a) or (b), (c)(2), and (d) in Table 402-1 for the mix class shown in the bid schedule.

(b) Submission. Delete the first sentence and substitute the following:

Submit written job-mix formulas with Form FHWA 1607 (Hveem) or Form 1622 (Marshall) for approval at least 28 days before production.

402.08 Asphalt Preparation. Delete the text and substitute the following:

Uniformly heat the asphalt binder to provide a continuous supply of the heated asphalt binder from storage to the mixer. Do not heat asphalt binder above 365 °F.

Federal Highway Administration
Revised Final Pavement Recommendation Memorandum
Chinquapin Intersection, Glacier Point Road
and Badger Pass Ski Area
Yosemite National Park
Project No. CA PRA-YOSE 15(1)
Mariposa County, California
AMEC Job No. 6-117-008002
April 15, 2008

402.09 Aggregate Preparation. Delete the text and substitute the following:

Adjust the aggregate moisture to at least 4 percent by mass of aggregate. Mix the lime uniformly with the aggregate before introducing the aggregate into the dryer or dryer drum. Use calibrated weighing or metering devices to measure the amount of lime and moisture added to the aggregate.

For batch plants, heat, dry, and deliver aggregate for pugmill mixing at a temperature sufficient to produce a mix temperature within the approved range. Adjust flames used for drying and heating to prevent damage to and contamination of the aggregate.

Control plant operations so the moisture content of the mix behind the paver is 0.5 percent or less according to AASHTO T 110 or T 255.

Add lime to the aggregate by Method A, B, or C below.

Method A - Add lime to the combined cold feed aggregate using an enclosed in-line cold feed mechanical pugmill mixer. Use a twin-shaft, continuous mixing pugmill with adjustable mixing paddles. Adjust the retention time of the mixture in the pugmill so no unmixed lime is visible after the lime and aggregate exit the pugmill.

Method B - Add lime to the produced aggregates during stockpiling using a pugmill. Add twenty-five (25) percent of the lime to be added to the coarse aggregate stockpile, and add seventy-five (75) percent of the lime to be added to the fine aggregate stockpile. When more than two stockpiles are used, include the distribution of lime per stockpile in the mix design.

A minimum moisture content of two (2) percent by dry weight for coarse aggregate and four (4) percent by dry weight for fine aggregate is required at the time the aggregates and lime are mixed.

Method C - Use a lime slurry consisting of one part lime and three parts water. Equip the plant with a mixing unit to allow mixing of the slurry and aggregate prior to entering the dryer or dryer drum.

Adjust the moisture of the coarse and fine aggregates, or combination of aggregates, to obtain uniform coating of the aggregate with the lime.

Prior to the production of hot asphalt concrete pavement, obtain approval of synchronized metering and weighing devices used to introduce a constant rate of lime and water.

Federal Highway Administration
Revised Final Pavement Recommendation Memorandum
Chinquapin Intersection, Glacier Point Road
and Badger Pass Ski Area
Yosemite National Park
Project No. CA PRA-YOSE 15(1)
Mariposa County, California
AMEC Job No. 6-117-008002
April 15, 2008

402.13 Placing and Finishing. Add the following to the fifth paragraph:

For simple curve widening locations (widening only on one side) shift the centerline joint location such that the final layer is midway between the normal edge of shoulders. The shift from the staked centerline will be towards the widened lane one-half the total curve widening specified for the given station as shown in the plans.

402.13 Placing and Finishing. Delete the fifth paragraph and substitute the following:

Make the longitudinal joint in the top layer along the existing striped centerline, as recorded under Subsection 152.03(n), or at the lane lines of roadways with more than two lanes.

402.13 Placing and Finishing. Add the following:

Use a Materials Transfer Vehicle (MTV) with storage and remixing capabilities on all mainline construction when placing asphalt concrete mixtures. The MTV will independently remix and deliver mixture from the hauling equipment to the paving equipment.

Furnish an MTV with the following capabilities:

- An unloading system to receive mixtures from the hauling equipment.
- A minimum storage capacity of 13 tons with a remixing system in the MTV storage bin.
- A discharge conveyor to deliver the mixture to the paver hopper.
- The MTV system cannot exceed maximum legal loadings on structures.

Acceptable Material Transfer Vehicles are:

- Barber Greene MTV-3500
- Roadtec SB-1500
- Roadtec SB-2500

In the event the MTV malfunctions during paving operations, the Contractor must suspend paving, however hot mix in transit and stored in the silo at the time of breakdown may be placed without the use of an MTV. Do not resume hot mix placement until the MTV is operational.

402.14 Compacting. Delete the text and substitute the following:

Furnish at least 3 rollers. Furnish one roller each for breakdown, intermediate, and finish rolling. At least one roller will be pneumatic-tired. Size the rollers to achieve the required results. Operate rollers according to the recommendation of the manufacturer. Diesel fuel will not be



Federal Highway Administration
Revised Final Pavement Recommendation Memorandum
Chinquapin Intersection, Glacier Point Road
and Badger Pass Ski Area
Yosemite National Park
Project No. CA PRA-YOSE 15(1)
Mariposa County, California
AMEC Job No. 6-117-008002
April 15, 2008

used as a release agent with any roller used to compact the asphalt mix. Do not cause cracking, shoving, or undue displacement. Continue rolling until all roller marks are eliminated, all cracks are sealed, and the required density is obtained. Do not roll the mix after the surface cools below 175 °F.

Monitor the compaction process with nuclear density gauges calibrated to the control strip core density test results. Compact to a pavement specific gravity (density) that is no less than 91.0 percent of the maximum specific gravity (density) determined according to AASHTO T 209.

Cut 6-inch diameter core sample from the compacted pavement according to AASHTO T 230, Method B. Fill and compact the core holes with asphalt concrete mixture. Label the cores and protect them from damage due to handling or temperature during storage. Perform specific gravity and thickness tests on the cores and deliver them to CO.

Along forms, curbs, headers, walls, and other places not accessible to the rollers, compact the mix with alternate equipment to obtain the required compaction.

Payment

402.19 Delete the third paragraph (paragraph above the pavement smoothness formula) and substitute the following:

When the contract contains provisions for hot asphalt concrete pavement and type I or II pavement smoothness, a separate adjustment will be made for pavement smoothness according to the following formula:

Delete the first sentence of the last paragraph on Page 246 and substitute the following:

When the contract contains provisions for hot asphalt concrete pavement and type III or IV pavement roughness, a separate adjustment will be made.

Table 402-3 Sampling and Testing Requirements. Add footnote (2) after Asphalt content in the Characteristic column:

⁽²⁾ Modify AASHTO T308, parts 8.2 and 10.2 to allow the use of AASHTO T 255, Total Evaporable Moisture Content of Aggregate by Drying.

ITEM 2 – Tack Coat

The tack coat will be as specified in Section 412 of the Standard Specification.



Federal Highway Administration
Revised Final Pavement Recommendation Memorandum
Chinquapin Intersection, Glacier Point Road
and Badger Pass Ski Area
Yosemite National Park
Project No. CA PRA-YOSE 15(1)
Mariposa County, California
AMEC Job No. 6-117-008002
April 15, 2008

For estimating purposes, the tack coat application rate is 0.15 gallons per square yard.

The Standard Specification 412 should be modified as follows in the Special Contract Requirements:

Section 412. - ASPHALT TACK COAT

Description

412.01 Delete the subsection and substitute the following:

412.01 This work consists of applying an emulsified asphalt or hot asphalt cement tack coat.

Tack coat emulsified asphalt grade will meet AASHTO T 140 or AASHTO T 208.

Tack coat asphalt cement grade will meet AASHTO M 20, M 226, or M 320

Measurement

412.08 Add the following after the second paragraph:

Indicate a breakdown of total emulsion and water added on the load invoices supplied to the CO for payment.

ITEM 3 – Rigid Pavement

Rigid Pavements will be constructed in accordance with Section 501 of the Standard Specifications.

The Standard Specification 501 should be modified as follows in the Special Contract Requirements:

Section 501. – RIGID PAVEMENT

Material

501.02 Add the following:

Reinforcing fibers 725.29



Federal Highway Administration
Revised Final Pavement Recommendation Memorandum
Chinquapin Intersection, Glacier Point Road
and Badger Pass Ski Area
Yosemite National Park
Project No. CA PRA-YOSE 15(1)
Mariposa County, California
AMEC Job No. 6-117-008002
April 15, 2008

SECTION IV - MISCELLANEOUS

ITEM 1 - Bituminous Pavement Removal

The work under this item consists of removing the existing bituminous pavement as specified in Section 203 of the Standard Specifications.

The Standard Specification 203 should be modified as follows in the Special Contract Requirements:

203.05 Disposing of Material.

(a) Remove from Project. Add the following to the end of the paragraph:

Secure environmental clearances according to Subsection 107.10.

(b) Burn. Delete the entire subsection.

(c) Bury. Delete the entire subsection.



Federal Highway Administration
 Revised Final Pavement Recommendation Memorandum
 Chinquapin Intersection, Glacier Point Road
 and Badger Pass Ski Area
 Yosemite National Park
 Project No. CA PRA-YOSE 15⁽¹⁾
 Mariposa County, California
 AMEC Job No. 6-117-008002
 April 15, 2008

TABLE 403-2
Sampling, Testing and Acceptance Requirements

Material or Property	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods or Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Hot Asphalt Concrete Pavement (design)	Measured and Tested for Conformance (106.04)	Job-mix formula verification	---	Subsection 403.02 ⁽¹⁾	1 per job-mix formula	Flowing mix stream (bin or belt discharge) or behind the laydown machine before rolling.	---	21 days before approval of job-mix formula
Hot Asphalt Concrete Pavement (production)	Measured and Tested for Conformance (106.04)	Job-mix formula verification	---	Subsection 403.02 ⁽¹⁾	1 per 700 ton	Behind the laydown machine before rolling.	Yes	24 hours
		Compaction ⁽²⁾	---	AASHTO T 166 and AASHTO T 209	1 per 700 ton	In-place after compaction.	"	"
		Smoothness	---	Subsection 403.08	---	---	---	---

⁽¹⁾ Use only sieves indicated on the job-mix formula for the specified gradation.

⁽²⁾ Cut core samples from the compacted pavement according to AASHTO T 230 Method B. Fill and compact the sample holes with asphalt concrete mixture.



Federal Highway Administration
Revised Final Pavement Recommendation Memorandum
Chinquapin Intersection, Glacier Point Road
and Badger Pass Ski Area
Yosemite National Park
Project No. CA PRA-YOSE 15(1)
Mariposa County, California
AMEC Job No. 6-117-008002
April 15, 2008

PAVEMENT DESIGN SUMMARY

**Re: Yosemite National Park
Chinquapin Intersection, Glacier Point Road & Badger Pass Ski Area
Pavement Reconstruction
Project No. CA PRA YOSE 15(1)
Mariposa County, California**

The following information summarizes the criteria used and decisions made in the design of pavements for the Yosemite Chinquapin Intersection, Glacier Point Road and Badger Pass Ski Area project. The information presented in the Final Materials Design Report is the result of these considerations.

1.0 INTRODUCTION

This Pavement Design Summary presents the designs developed for flexible pavements for the proposed improvements to Yosemite National Park. The design of the pavement incorporated information from a previous pavement investigation performed by Klienfelder, Inc. (2006a).

The pavement design was performed by AMEC Earth & Environmental, Inc.

This summary report includes a brief description of the geotechnical profile. Geotechnical investigations and laboratory testing was not performed for this project.

2.0 PROJECT DESCRIPTION

The project includes reconstruction of the Chinquapin Intersection on Wawona Road to provide better sight distance and improved turning radii to and from Glacier Point Road. The existing parking areas at the intersection will be reconfigured. Glacier Point Road will receive pavement improvements along with subgrade subexcavation at designated locations. The Badger Pass Ski Area Access Road and Parking Area will also receive pavement improvements. The project purpose is to rehabilitate, restore and resurface (3R) the pavements. The project includes 0.31 miles on Wawona Road, 5.06 miles along Glacier Point Road and 0.10 miles along the Badger Pass Ski Area.



Federal Highway Administration
Revised Final Pavement Recommendation Memorandum
Chinquapin Intersection, Glacier Point Road
and Badger Pass Ski Area
Yosemite National Park
Project No. CA PRA-YOSE 15(1)
Mariposa County, California
AMEC Job No. 6-117-008002
April 15, 2008

3.0 EXISTING PAVEMENT AND SUBSURFACE CONDITIONS

3.1 Existing Pavement Conditions

3.1.1 Wawona Road

The pavements exhibit moderate severity fatigue cracking and low to moderate transverse, longitudinal and block cracking. The cracks have not been sealed. Patching and thin surface treatment overlays are present within the project limits. Some raveling of the pavement surface can be attributed to tire chains and snow plows.

The parking areas at the Chinquapin Intersection have moderate to high severity block cracking. The transitions from the parking areas to the main roadway have edge cracking and potholes have formed.

Pavement cores were obtained along Wawona Road at the Chinquapin Intersection. A summary of the results of the pavement coring is as follows:

Pavement Core Number	Location	Existing Pavement Section
PC-1	Restroom Parking Area, Sta. 17+80, R 25'	6" AC over 14" AB
PC-2	Existing Parking Area, Sta. 22+00, R 40'	4.5" AC over 9.5" AB
PC-3	Wawona Road, Sta. 24+15, L 5'	5.5" AC over 10" AB

3.1.2 Glacier Point Road

The pavement conditions along Glacier Point Road are described in the Klienfelder report (2006a). The pavements are nearing the end of their service life and exhibit moderate to high severity fatigue cracking and edge cracking. Longitudinal and transverse cracking are also present. Rutting of the outside wheel path, ranging from 0.5 to 2.0 inches, was observed. Areas of the pavement with the fatigue cracking have resulted in potholes. The potholes have been patched over several seasons. Some of the patching has also deteriorated.

From the seven cores obtained along the roadway segment, the asphaltic concrete thickness ranged from 3.1 to 6.5 inches in 3 to 4 lifts, and the aggregate base thickness ranged from 1.0 to 7.5 inches. It was noted that the middle lift of asphaltic concrete appeared to be an open graded mixture and has stripping of the asphalt cement and resultant raveling. The pavement core results are presented in the Klienfelder (2006a) report.

Federal Highway Administration
Revised Final Pavement Recommendation Memorandum
Chinquapin Intersection, Glacier Point Road
and Badger Pass Ski Area
Yosemite National Park
Project No. CA PRA-YOSE 15(1)
Mariposa County, California
AMEC Job No. 6-117-008002
April 15, 2008

3.1.3 Badger Pass Ski Area

The Badger Pass access road and parking area pavements are beyond their service life. High severity fatigue cracking is common throughout. Numerous potholes were observed both during the Klienfelder (2006a) site inspections and subsequent visits.

Based on the two cores obtained in the area, the asphaltic concrete thickness varies from 6.0 to 6.5 inches, and the aggregate base thickness varies from 3.5 to 8.0 inches.

3.2 Subgrade Conditions

Both the AMEC and Klienfelder (2006b) investigations at the Chinquapin Intersection encountered low density silty sands and sandy silts to depths ranging from 10 to about 30 feet below existing site grades. Any increase in elevation of the roadway profile could induce settlements of these soils and will need to be evaluated.

The pavement distress observed was a result of aging, excessive traffic, extensive use of tire chains and subgrade failure (Klienfelder, 2006a). The construction drawings for the project present the limits of recommended subgrade subexcavation along Glacier Point Road. These limits should be evaluated again immediately prior to the project going to advertisement.

3.3 Pavement Subgrade Support

An R-value of 30 was selected for design. Using correlations to account for a decrease in the subgrade soil strength within a climatic zone of a high mountainous region, a resilient modulus of 7,780 pound per square inch was assigned.

4.0 FLEXIBLE PAVEMENT DESIGN

Flexible pavement designs outlined in the following sections were completed in accordance with the AASHTO Guide for Design of Pavement Structures (1993). The Guidelines for Completing the Pavement Investigation and Report (CFLHD, 2005) were used in assigning design parameters and in the selection of the pavement components. The subgrade conditions for Glacier Point Road and the Badger Pass Ski Area were assigned based on a previous pavement evaluation performed for the project (Klienfelder, 2006a). The Standard Specifications and Special Contract Requirements referenced in the Materials Report are Federal Project 2003 Standard Specifications (FP-03) in the U.S. Customary Measure Units.

The pavement design for the project has been developed using the concept of Full Depth Reconstruction (FDR). As described in the Basic Asphalt Recycling Manual (ARRA, 2001), FDR is the technique in which the full thickness of the asphalt pavement and a predetermined



Federal Highway Administration
 Revised Final Pavement Recommendation Memorandum
 Chinquapin Intersection, Glacier Point Road
 and Badger Pass Ski Area
 Yosemite National Park
 Project No. CA PRA-YOSE 15(1)
 Mariposa County, California
 AMEC Job No. 6-117-008002
 April 15, 2008

portion of the underlying materials (base, subbase or subgrade) is uniformly pulverized and blended to provide an upgraded, homogeneous base course material. The base course can either be the pulverized blend alone or can be stabilized.

4.1 Pavement Design Parameters

The traffic data presented in the 2004 Yosemite National Park Traffic Data Report (National Park Service, 2004) was used to determine traffic loading. For design, the 2008 AADT data was selected for the initial year. The 2008 Annual Average Daily Traffic (AADT) on the segment of Wawona Road at the Chinquapin Intersection was 3097. The 2008 AADT for the Glacier Point Road is 1532. The Badger Pass Access Road 2008 AADT is 1050. A traffic growth rate of 1 percent increase in visitation per year, and a 50 percent direction factor were assigned.

The distribution of the amount and type of traffic was assigned using the vehicle data collected on the South Entrance Road between Mariposa Grove Road and the South Park Boundary:

FHWA Vehicle Description & Classification	Percentage	ESAL Factor	Comments
Motorcycle – Class 1	0.41	0.0000	
Automobile – Class 2	92.30	0.0008	
RV	2.74	0.2000	2 axle, 6 tire (Most RVs are Class C)
Vehicle/RV with Trailer	2.02	0.2000 +0.0004	2 axle, 6 tire + auto
Bus and Tour Bus	0.51	0.88	
Light Duty Truck – Classes 3 & 5	1.71	½ @ 0.0122 ½ @ 0.5000	2 axle, 4 tire 2 axle, 6 tire
Heavy Truck – Classes 6-13	0.31	2.25	
TOTAL	100		

The total traffic volume (TTV one way) and calculated ESAL loading for each road segment are as follows:

Road Segment	Total Traffic Volume	Equivalent Single Axle Loadings (ESALs)
Wawona Road	11,305,366	295,169
Glacier Point Road	6,177,058	161,276
Badger Pass Ski Area	4,233,464	110,531



Federal Highway Administration
 Revised Final Pavement Recommendation Memorandum
 Chinquapin Intersection, Glacier Point Road
 and Badger Pass Ski Area
 Yosemite National Park
 Project No. CA PRA-YOSE 15(1)
 Mariposa County, California
 AMEC Job No. 6-117-008002
 April 15, 2008

4.2 Combined Standard Error and Level of Reliability

An overall standard deviation of 0.49 was used for design of flexible pavements. A reliability level of 75 percent was assigned. The associated standard normal deviate (Z_r) for the assigned reliability level is -0.674 .

4.3 Serviceability Level

Initial and terminal values of the serviceability index were selected as follows:

Initial Serviceability – P_o	=	4.2
Terminal Serviceability – P_t	=	2.5
Change in Serviceability -	=	1.7

4.4 Structural Number Calculation

Using the design parameters described above, the required Structural Number (SN) was calculated for each road segment (see attached calculation sheets). The results of the calculations are as follows:

Road Segment	Required Structural Number
Wawona Road	2.55
Glacier Point Road	2.30
Badger Pass Ski Area	2.16

For design, the following structural and drainage coefficients were selected for the pavement section components.

Pavement Component	Drainage Coefficient	Structural Coefficient
Asphaltic Concrete (AC) (Item 402 – Hot Asphalt Concrete)	1.0	0.44
Base Course – Full Depth Asphalt Rehabilitation (Item 303)	1.0	0.12
Aggregate Base (Item 308)	1.0	0.10

Using the above design criteria, the following flexible pavement sections are recommended for Wawona Road:



Federal Highway Administration
 Revised Final Pavement Recommendation Memorandum
 Chinquapin Intersection, Glacier Point Road
 and Badger Pass Ski Area
 Yosemite National Park
 Project No. CA PRA-YOSE 15(1)
 Mariposa County, California
 AMEC Job No. 6-117-008002
 April 15, 2008

Pavement Component	Thickness (inches)	Drainage Coefficient	Structural Coefficient	Structural Number
AC	4.0	1.0	0.44	1.76
Pulverized AC	7.0	1.0	0.12	0.84
Existing or New AB	3.0	1.0	0.10	<u>0.30</u>
				2.90

The following flexible pavement sections are recommended for Glacier Point Road from Sta. 0+98.17 to 5+00:

Pavement Component	Thickness (inches)	Drainage Coefficient	Structural Coefficient	Structural Number
AC	4.0	1.0	0.44	1.76
AB	9.0	1.0	0.10	<u>0.90</u>
				2.66

The following flexible pavement sections are recommended for Glacier Point Road from Sta. 5+00 to 268+08.2:

Pavement Component	Thickness (inches)	Drainage Coefficient	Structural Coefficient	Structural Number
AC	3.0	1.0	0.44	1.32
Pulverized AC	8.0	1.0	0.12	<u>0.96</u>
				2.28

The structural number does not meet the design structural number but is acceptable due to the performance of the existing pavement section and subgrade conditions.

The following flexible pavement sections are recommended for the Badger Pass Ski Area Access Road (Sta. 64+67 to 69+97):

Pavement Component	Thickness (inches)	Drainage Coefficient	Structural Coefficient	Structural Number
AC	4.0	1.0	0.44	1.76
AB	9.0	1.0	0.10	<u>0.90</u>
				2.66



Federal Highway Administration
 Revised Final Pavement Recommendation Memorandum
 Chinquapin Intersection, Glacier Point Road
 and Badger Pass Ski Area
 Yosemite National Park
 Project No. CA PRA-YOSE 15(1)
 Mariposa County, California
 AMEC Job No. 6-117-008002
 April 15, 2008

The following flexible pavement sections are recommended for the Badger Pass Ski Area Parking:

Pavement Component	Thickness (inches)	Drainage Coefficient	Structural Coefficient	Structural Number
AC	3.0	1.0	0.44	1.32
Pulverized AC	7.0	1.0	0.12	0.84
Existing or New AB	3.0	1.0	0.10	<u>0.30</u> 2.43

The recommended pavement section for the Badger Pass Bus Pads is as follows:

Pavement Component	Thickness (inches)
PCCP	6.0
AB	4.0



Federal Highway Administration
Revised Final Pavement Recommendation Memorandum
Chinquapin Intersection, Glacier Point Road
and Badger Pass Ski Area
Yosemite National Park
Project No. CA PRA-YOSE 15(1)
Mariposa County, California
AMEC Job No. 6-117-008002
April 15, 2008

5.0 REFERENCES

American Association of State Highway and Transportation Officials, 1993, AASHTO Guide for Design of Pavement Structures, Washington, D.C.

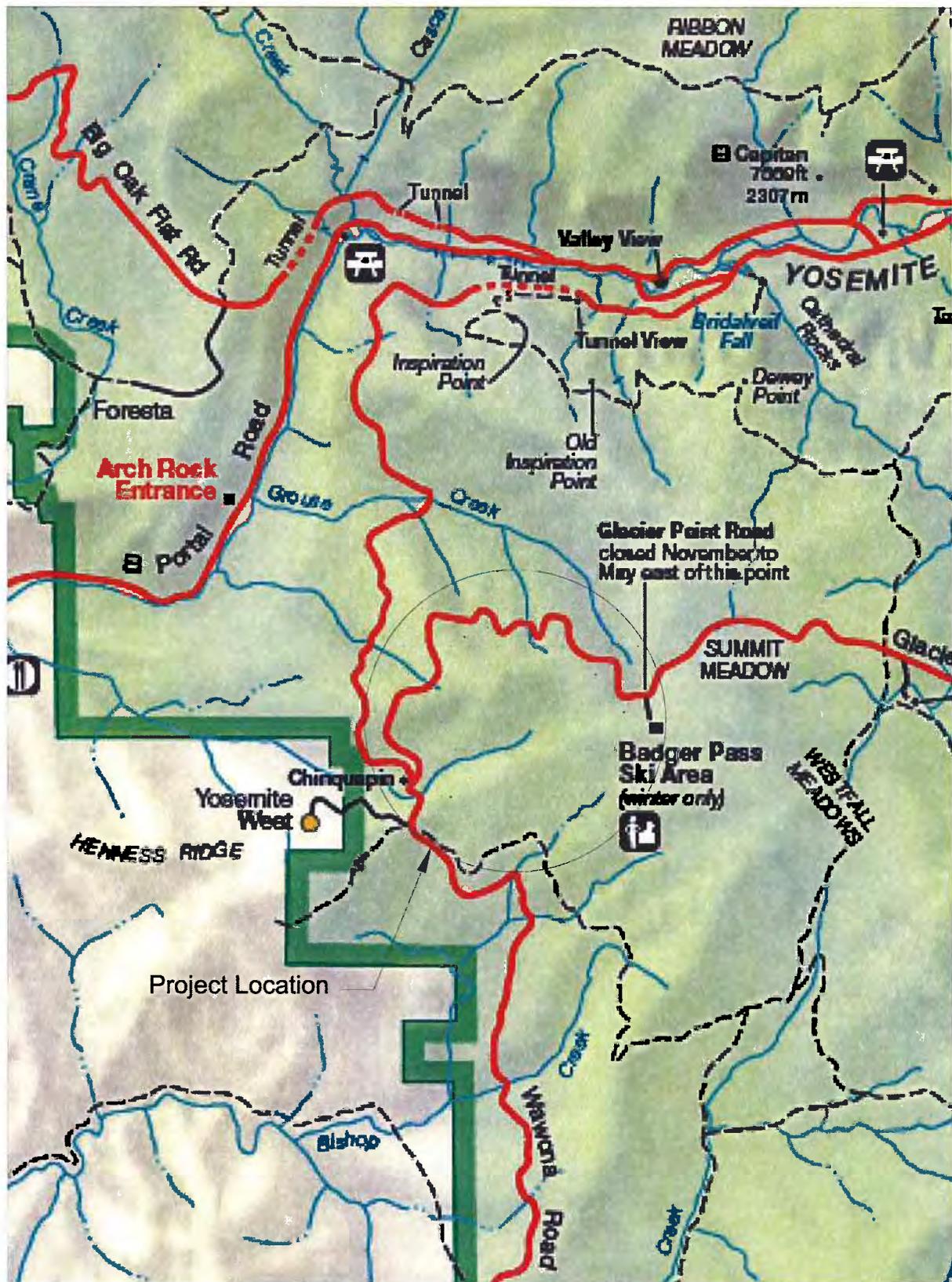
Asphalt Recycling and Reclaiming Associated, 2001, Basic Asphalt Recycling Manual, published in association with U.S. Department of Transportation, Federal Highway Administration.

Central Federal Lands Highway Division, 2005, Guidelines for Completing the Pavement Investigation and Report.

Kleinfelder, Inc., 2006a, Pavement Investigation Report, Glacier Point Road, Yosemite National Park, Project No. CA PRA YOSE 15(1), dated April 25, 2006.

Kleinfelder, Inc., 2006b, Preliminary Geotechnical Evaluation Memorandum, Glacier Point Road and the Chinquapin Intersection, Yosemite National Park, Project No. CA PRA YOSE 15(1), dated April 11, 2006.

National Park Service, 2004 Traffic Data Report, Yosemite National Park Traffic Package, 22 pages.



JOB NO.: 6-117-008002

DESIGN: TJF

DRAWN: GWH

DATE: 5/2007

SCALE: N.T.S.

PROJECT LOCATION MAP YOSEMITE NATIONAL PARK

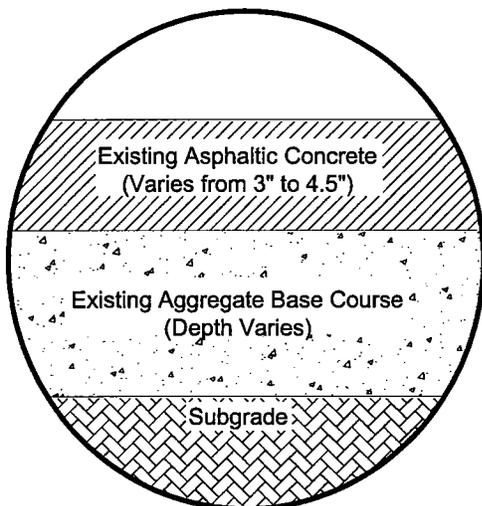
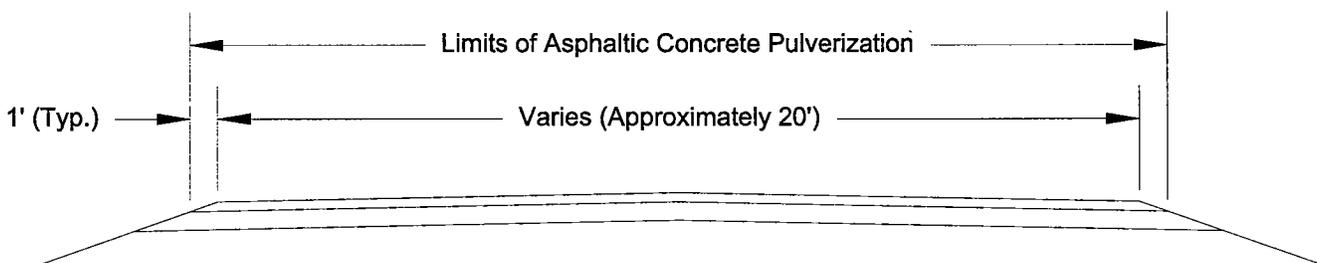
PAVEMENT & ROADWAY
IMPROVEMENTS
PROJECT NO. CA PRA-YOSE 15(1)



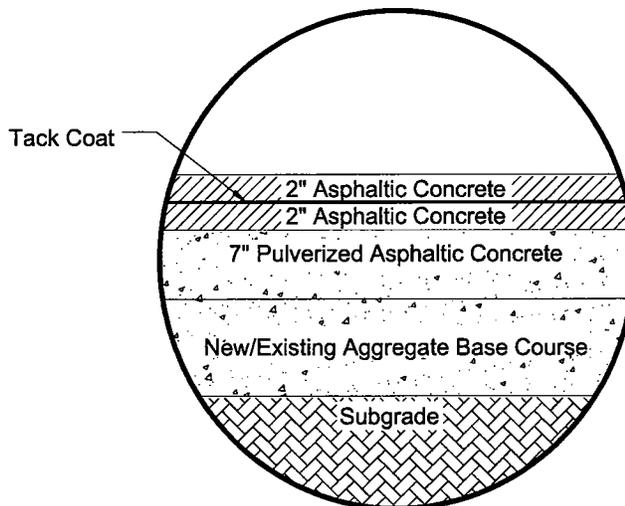
TYPICAL PAVEMENT SECTION

WAWONA ROAD - STA. 14+00 to 30+50
 CHINQUAPIN INTERSECTION RESTROOM PARKING AREA
 CHINQUAPIN INTERSECTION BUS PARKING AREA

YOSEMITE NATIONAL PARK
 PAVEMENT & ROADWAY IMPROVEMENTS
 PROJECT NO. CA PRA YOSE 15(1)



EXISTING PAVEMENTS



NEW PAVEMENTS

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JOB NO.: 6-117-008002

DESIGN: TJF

DRAWN: GWH

DATE: 12/2007

SCALE: N.T.S.

TYPICAL PAVEMENT SECTION 1
 YOSEMITE NATIONAL PARK

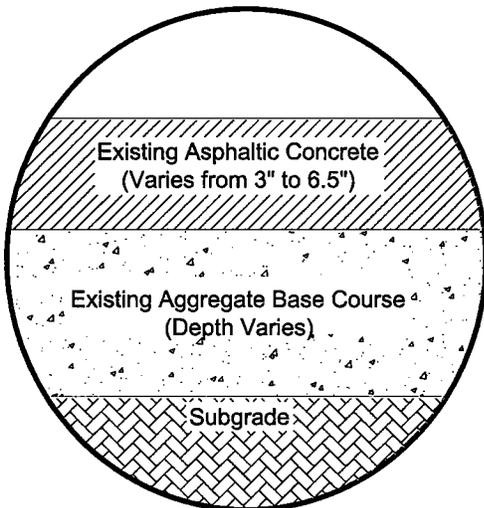
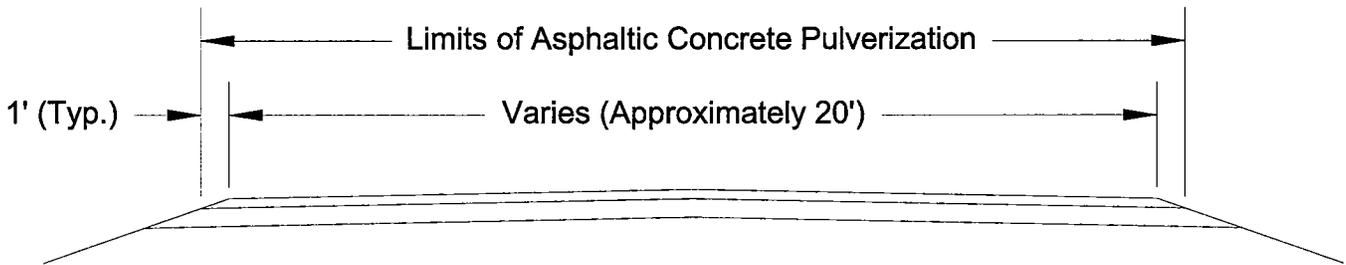
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 PROJECT NO. CA PRA YOSE 15(1)



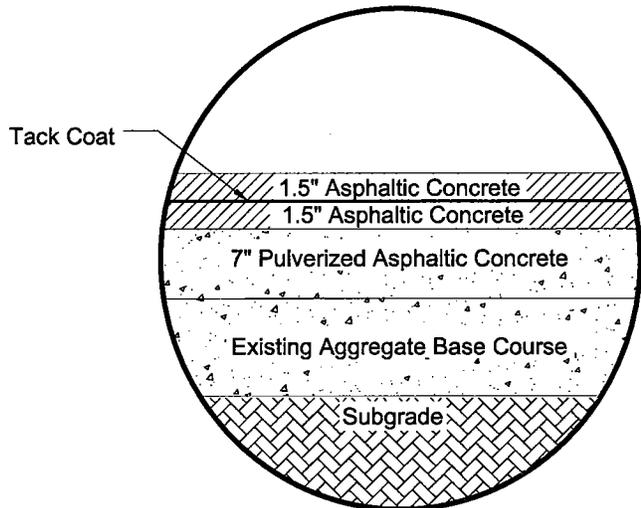
TYPICAL PAVEMENT SECTION

BADGER PASS SKI AREA PARKING LOTS

YOSEMITE NATIONAL PARK
PAVEMENT & ROADWAY IMPROVEMENTS
PROJECT NO. CA PRA YOSE 15(1)



EXISTING PAVEMENTS

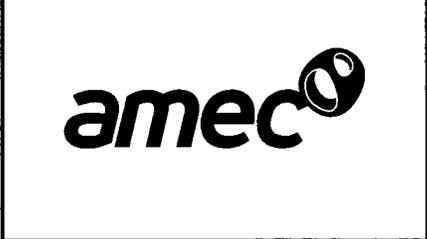


NEW PAVEMENTS

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DESIGN:	TJF
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DATE:	12/2007
SCALE:	N.T.S.

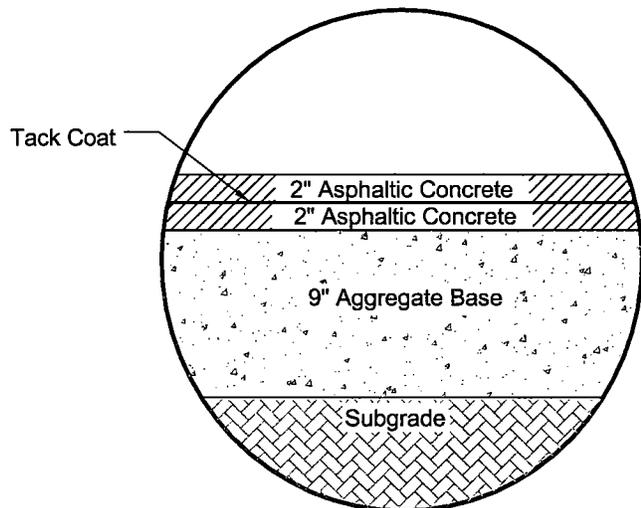
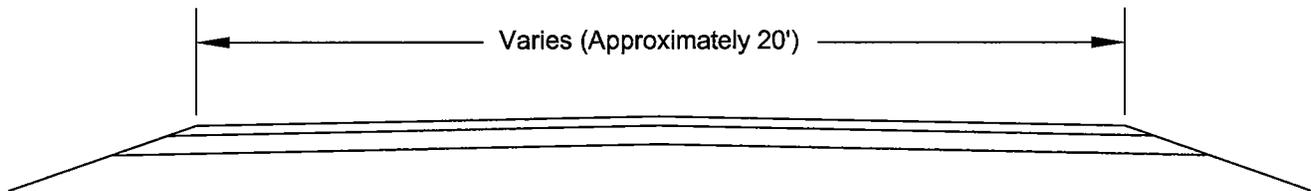
TYPICAL PAVEMENT SECTION 2 YOSEMITE NATIONAL PARK	
PAVEMENT & ROADWAY IMPROVEMENTS PROJECT NO. CA PRA YOSE 15(1)	



TYPICAL PAVEMENT SECTION

BADGER PASS SKI AREA ACCESS ROAD - STA. 64+67 to 69+98
 GLACIER POINT ROAD - STA. 0+98.1 to 5+00

YOSEMITE NATIONAL PARK
 PAVEMENT & ROADWAY IMPROVEMENTS
 PROJECT NO. CA PRA YOSE 15(1)



NEW PAVEMENTS

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JOB NO.: 6-117-008002

DESIGN: TJF

DRAWN: GWH

DATE: 12/2007

SCALE: N.T.S.

TYPICAL PAVEMENT SECTION 3
 YOSEMITE NATIONAL PARK

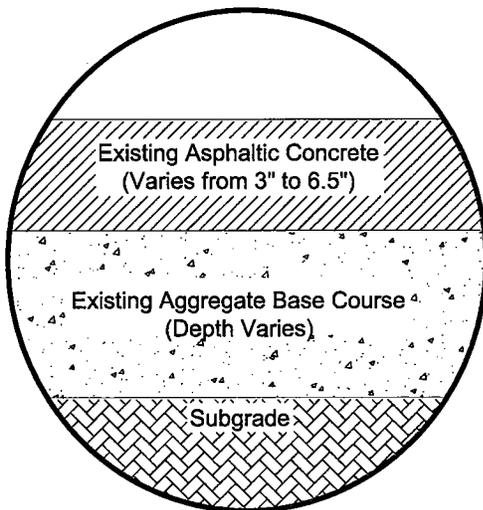
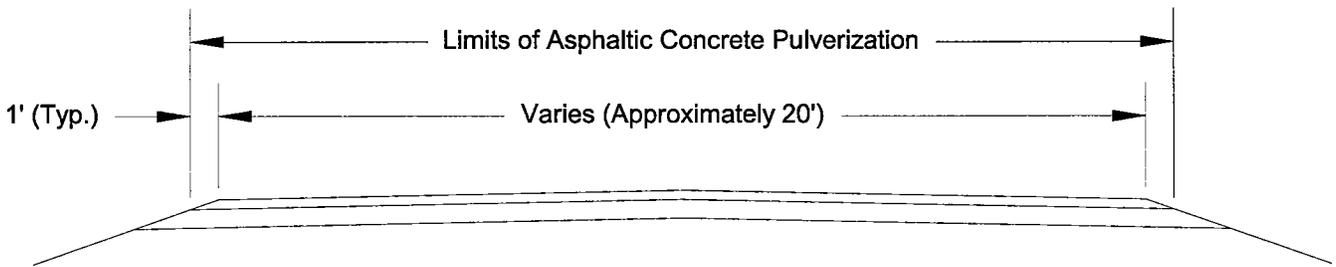
PAVEMENT & ROADWAY IMPROVEMENTS
 PROJECT NO. CA PRA YOSE 15(1)



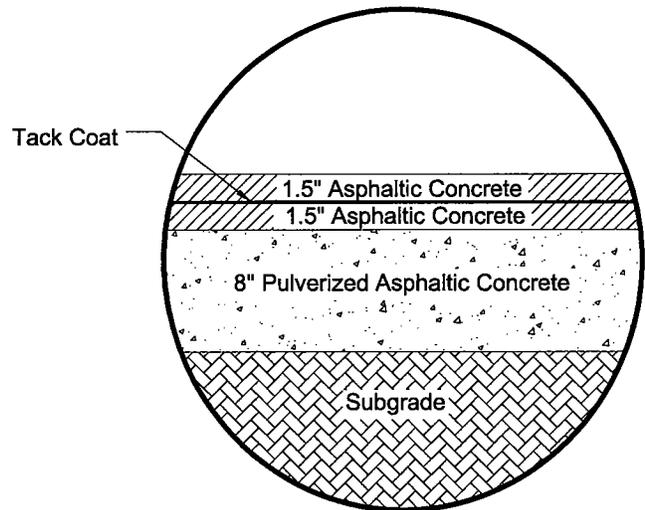
TYPICAL PAVEMENT SECTION

GLACIER POINT ROAD - STA. 5+00 TO 268+08

YOSEMITE NATIONAL PARK
PAVEMENT & ROADWAY IMPROVEMENTS
PROJECT NO. CA PRA YOSE 15(1)



EXISTING PAVEMENTS



NEW PAVEMENTS

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JOB NO.: 6-117-008002	TYPICAL PAVEMENT SECTION 4 YOSEMITE NATIONAL PARK	
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DRAWN: GWH	PAVEMENT & ROADWAY IMPROVEMENTS PROJECT NO. CA PRA YOSE 15(1)	
DATE: 12/2007		
SCALE: N.T.S.		

Jacobs Civil, Inc.
 Initial Pavement Recommendations Memorandum
 Chinquapin Intersection, Glacier Point Road
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 Project No. CA PRA YOSE 15(1)
 Mariposa County, California
 AMEC Project No. 6-117-008002

Wawona Road (Chinquapin Intersection) Pavement Design

Design R-value	30.00	Seasonal Variation Factor	4
Calculated Resilient Modulus ADOT Recommended	7781 psi	$M_R = \frac{1815 + 225 * R_{mean} + 2.4 * R_{mean}^2}{0.6 * SVF^{0.6}}$	
Maximum Resilient Modulus Design Resilient Modulus	26000 psi 7780 psi		
Standard Normal Deviate	-0.674	75%	Equivalent 18-k Single Axle Loads 295,169
Standard Error	0.49		
Design Sevicability Loss	1.7	75%	Structural Number 2.55

$$\log_{10}(W_{18}) = Z_R * S_O + 9.36 * \log_{10}(SN + 1) - 0.20 + \frac{\log_{10} \frac{\Delta PSI}{4.2 - 1.5}}{0.40 + \frac{1094}{(SN + 1)^{5.19}}} + 2.32 * \log_{10}(M_R) - 8.07$$

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 Chinquapin Intersection, Glacier Point Road
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 Project No. CA PRA YOSE 15(1)
 Mariposa County, California
 AMEC Project No. 6-117-008002

Glacier Point Road Pavement Design

Design R-value	30.00	Seasonal Variation Factor	4
Calculated Resilient Modulus ADOT Recommended	7781 psi	$M_R = \frac{1815 + 225 * R_{mean} + 2.4 * R_{mean}^2}{0.6 * SVF^{0.6}}$	
Maximum Resilient Modulus Design Resilient Modulus	26000 psi 7780 psi		
Standard Normal Deviate	-0.674	75%	Equivalent 18-k Single Axle Loads 161,276
Standard Error	0.49		
Design Sevicability Loss	1.7	75%	Structural Number 2.30

$$\log_{10}(W_{18}) = Z_R * S_O + 9.36 * \log_{10}(SN + 1) - 0.20 + \frac{\log_{10} \frac{\Delta PSI}{4.2 - 1.5}}{1094} + 2.32 * \log_{10}(M_R) - 8.07$$

$$0.40 + \frac{(SN + 1)^{5.19}}{(SN + 1)^{5.19}}$$

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 Chinquapin Intersection, Glacier Point Road
 and Badger Pass Ski Area
 Project No. CA PRA YOSE 15(1)
 Mariposa County, California
 AMEC Project No. 6-117-008002

Badger Pass Ski Area Pavement Design

Design R-value	30.00	Seasonal Variation Factor	4
Calculated Resilient Modulus ADOT Recommended	7781 psi	$M_R = \frac{1815 + 225 * R_{mean} + 2.4 * R_{mean}^2}{0.6 * SVF^{0.6}}$	
Maximum Resilient Modulus Design Resilient Modulus	26000 psi 7780 psi		
Standard Normal Deviate	-0.674	75%	Equivalent 18-k Single Axle Loads
Standard Error	0.49		110,531
Design Servicability Loss	1.7	75%	Structural Number
			2.16

$$\log_{10}(W_{18}) = Z_R * S_O + 9.36 * \log_{10}(SN + 1) - 0.20 + \frac{\log_{10} \frac{\Delta PSI}{4.2 - 1.5}}{1094} + 2.32 * \log_{10}(M_R) - 8.07$$

$$0.40 + \frac{(SN + 1)^{5.19}}{(SN + 1)^{5.19}}$$