

MS-
TIS

States (CO)
1994-10

10

Denver Metropolitan Area Asphalt Pavement Mix Design Recommendations

Prepared by
Metro Mix Design Task Force

Prepared for
**Denver Metropolitan Government
Pavement Engineers Council**

October 1994

Contents

Introduction.....	1
The Task Force.....	1
Problem Statement.....	2
Issues Discussion.....	3
Types of Facilities.....	3
Quality.....	3
Aggregate Gradation.....	4
Anti-Strip Additives.....	5
Recycled Asphalt.....	5
Asphalt Type.....	5
Laboratory Tests for Stability and Durability.....	5
Field Project Performance.....	6
Metro Mix Design Recommendations.....	6
Other Recommendations.....	7
Summary.....	11
Appendix.....	12
References.....	27

Introduction

The state-of-the-practice for the design of asphalt pavements in the Denver Metropolitan area is the result of many years of change and new ideas. As new technology becomes available, many local city and county agencies will adopt the change, whereas; others will continue with their historic methods. Consequently, a variety of asphalt pavement material specifications are being used by the various local governments and their design consultants. It has been estimated that over 60 asphalt mix designs are being specified in the Denver metropolitan area.

These multiple designs become difficult for the asphalt mix producers to manufacture. As material batches are ordered for delivery to these various agencies, the producers are required to constantly change their mixing formulations and plant operations. This constantly changing process results in inefficiencies in production time and cost to the buyer, as well as variability in the process. The problem is intensified when towns and communities order small amounts of material for a local street project.

In March, 1994 a Government Forum was held in conjunction with the annual meeting of the Colorado Asphalt Pavement Association(CAPA). At this forum, a decision was made to organize a Task Force to address this problem and provide recommendations for asphalt paving materials in the Denver Metropolitan area. This report presents the recommendations of that Task Force.

The Task Force

At the CAPA Government Forum it was decided to establish a Asphalt Pavement Performance Task Force of the following individuals:

- John Cheever, Bituminous Roadways of Colorado (BROC)
- Denis Donnelly, Task Force Chair
- Thom Ferguson, City of Aurora
- Bob LaForce, Colorado Dept. of Transportation (CDOT)
- Dave Potter, City of Denver
- Scott Sands, Federal Highway Administration (FHWA) - Colorado Division
- Rich Zamora, FHWA - Region 8

The Task Force was asked to provide recommendations to the Denver Metropolitan Government Pavement Engineers Council (DMGPEC) for their consideration and implementation.

Problem Statement

General issues identified at the Forum and suggested for consideration by the Task Force are as follows:

The multiple asphalt pavement design mixtures used by the government agencies in the Denver Metropolitan area

Identification of performance aspects for asphalt pavements

How does the customer identify performance/quality

Uniformity of procedures for performing pavement distress surveys and dealing with pavement management issues

QA/QC specifications as well as technician certification

Other asphalt paving issues.

At the first meeting of the Task Force, the following additional issues were identified:

Quality and the measurement of quality

Material selection guidelines based on

Level of service

Type of facility

Geology

Traffic Loadings/ESAL's

Environment (only one in Denver metro area)

Need for historic traffic data base

Designs for local streets that provide long term performance while resisting rutting due to urban traffic conditions such as trash trucks and busses.

Publicize standard mix design procedures. Metro-wide awareness of standard and state-of-the-art mixes to minimize number of designs.

In order to address the above problems, the Task Force identified the following guidelines:

- It was intended to synthesize the state-of-the-practice used for asphalt pavement mix designs in the Denver Metropolitan area.
- When multiple mix design procedures existed, the Task Force would recommend those that reflected quality and



L021488

cost effective performance.

- In some cases quality materials could be produced naturally by asphalt pavement producers. Even though they were not specified in existing standards they would be recommended by the Task Force.
- If quality features could be incorporated into the recommendations without adversely affecting the producer or owner agencies, either financially or from a production standpoint, they would be included.

Issues Discussion

Many of the issues presented at the CAPA forum and identified by the Task Force were beyond the scope and outside the expertise of the Task Force and its members. These included issues pertaining to pavement management and structural design. These issues should be referred back to the Metropolitan Government Pavement Engineers Council for their consideration, possibly by another Task Force. Thus, the Metro Denver Asphalt Mix Design Task Force decided to confine its attention to the asphalt material mixture and associated properties.

Types of Facilities

Typical facilities found in the Denver metro area include freeways, major arterial, arterial, collector, and residential streets. These are the classifications addressed in the asphalt pavement mix designs. From time to time, circumstances dictate "specialty" mixes to be placed on these facilities. It was decided that the Task Force would only address those mix designs that were standard for these facilities. Thus, "specialty" items such as the use of polymers, Stone Mastic Asphalt, and other unique performance-related mixtures or additives would be specified on a project by project basis. Because of the case-by-case application of these mixtures they are not included in the Task Force recommendations.

Quality

Although many variables exist within the asphalt paving mixture, the Task Force decided that the recommendations would address quality of materials, construction, and performance. Although there may be other factors and variations on the materials specified in the Task Force recommendations, the identified specifications should provide adequate benefit/cost in terms of long term performance.

In addition, the findings from the Strategic Highway Research Program (SHRP) are considered as state-of-the-art. Therefore, many of the recommended materials properties are those identified by SHRP and the SUPERPAVE™ asphalt pavement design procedures.

Aggregate Gradation

The principal factor contributing to variability of asphalt paving mixes is the gradation of the aggregates. Many agencies use a variety of sieve sizes as well as target values in terms of percent passing those sieves. The use of recycled material is also a contributing variable. The Task Force decided to confine its recommendations to Grading C (3/4" nominal size), Grading CX (1/2"), and Grading G (1") specifications. The Denver Gradation Q (3/4") mix was also included as a recommendation. Aggregate gradations outside these specifications are considered as "specialty" items such as Stone Mastic Asphalt (SMA) mixes.

The use of **natural fines** is currently being investigated. However, 20 percent or less natural fines is suggested as an interim recommendation. Fine material properties will ultimately be based on the National Stone Association angularity tests when future validation is made available.

The Task Force recommendations for fines (P 200) is as follows:

3-6% without lime

3-7% with lime

Production tolerances will be $\pm 2\%$ of Job Mix Formula.

Although aggregate gradations have been recommended, the Task Force felt that voids acceptance specifications will ultimately replace the need to specify individual screen sizes. The specification of Voids in the Mineral Aggregate (VMA) and other volumetric properties will ultimately place the responsibility of providing a good performing gradations on the aggregate/asphalt pavement contractor. These recommendations will emerge following research investigations currently underway.

The AASHTO T-96 test procedure will be used for aggregate **L.A. Abrasion** with a maximum value of 40 specified. (Lower values should be considered for high traffic volume facilities).

Aggregate **Sand Equivalent** greater than 45 using AASHTO T-176 will be specified.

Anti-Strip Additives

The state-of-the-practice is to use various additives to prevent stripping of asphalt pavement due to moisture damage. In many cases, local agencies often use less expensive commercially available anti-strip additive. The city of Aurora typically uses 0.5% Pave Bond Special. However, as referenced by Aschenbrener¹, "the use of hydrated lime improved the test results dramatically" and "Mixes treated with liquid anti-stripping additives did not perform as well as those treated with lime". If a quality mix is being specified, as is the intent of the Task Force recommendations, the use of **hydrated lime** is recommended.

Recycled Asphalt

The use of Recycled Asphalt Pavement (RAP) was not treated separately as a unique asphalt pavement mixture. It was included as a permissible item with the maximum percent allowable. It is understood that the material to be used will not be contaminated with clay, soil, or other non-asphaltic materials.

Asphalt Type

Since the majority of the Denver Metropolitan area (excluding Boulder and Jefferson County mountainous area) is in one climatic zone, as identified by SHRP, the Task Force recommends that AC-10 asphalt cement be specified on all standard paving projects. The use of harder based asphalt (e.g. AC-20), polymers, and other additives may be specified as "specialty" projects which were not addressed by the Task Force. (Note: The use of performance grade asphalts, as recommended by SHRP, should be considered in the future.)

Laboratory Tests for Stability and Durability

The city of Denver, Colorado DOT, and several major contractors in the metro area use the Gyratory compactor when designing or evaluating asphalt mix properties. The remainder, and majority, of the cities and counties use the Marshall mix design method. Many consultants and contractors have both capabilities.

The majority (>60 percent) of the mixes used by metropolitan government agencies are designed with 50 blow Marshall method. Recent CDOT research has indicated that this is virtually equivalent to 50 psi end point stress with the Texas Gyratory compactor. Another 20 percent are designed with 75 blow Marshall or approximately 75 psi end point stress. The remaining 20 percent are "specialty" mixes. Design mix factors used by the Task Force concentrated on the 50 and 75 blow Marshall mix design methods.

¹ Aschenbrener, T. and N. Far (1994), "Influence of Compaction Temperature and Anti-Stripping Treatment on Results from the Hamburg Wheel-Tracking Device," Colorado Department of Transportation, CDOT-DTD-R-94-9.

Specifications for the Lottman durability tests are based on research and data collected by the Colorado DOT. Task Force recommendations are based on these findings. Colorado DOT is currently recommending to AASHTO to perform the Lottman test at 100% saturation. This will be considered by the Task Force for adoption in the future.

Field Project Performance

Actual field performance and constructability of many of the Task Force recommendations was of concern to the members. To satisfy some of these concerns, twelve asphalt paving projects constructed with specifications similar to those being recommended by the Task Force were observed in the field.

For each of the projects, varying in age from 1 to 8 years, the Task Force observed the pavement surface distress - identifying the type and estimating relative level of severity. As-constructed mix design properties with available production test results were also provided by the local agency. This as-constructed information was compared to the observed distress and used in evaluating the mix design proposals.

Appendix A contains the EVALUATION CHECKLIST for each of the twelve projects evaluated. This information ultimately provided the justification and verification for many of the Task Force recommendations. Many of the features being considered were incorporated into these construction projects. It was observed that the gradation and material properties being recommended were constructable and over the lifetime of the observed projects performed relatively well. However, it was also felt that **quality is achieved only when good gradation and materials properties are accompanied by good pavement design and construction practices.**

Metro Mix Design Recommendations

The Task Force recommendations for asphalt pavement mix design and master range specifications are contained in Table A. These recommendations include gradation, asphalt cement type, additives, RAP, voids, and laboratory design properties. Four standard mixes were identified: Gradings CX (EX), C (E), Q, and G. Other specific mix design features not included in Table A are found in the **Issue Discussion** section of this report. Additional asphalt pavement mix design types not included are considered "specialty" mixes and should be designed on a project by project basis.

It is also recognized that the information listed in Table A is state-of-the-art as opposed to state-of-the-practice. It was the intent of the Task Force to present a quality product using available technology. As new technology emerges revisions to these recommendations are expected.

In addition to making modifications to this table because of "specialty" needs, local agencies may be tempted to make minor changes for economic reasons. Such action is not recommended. As deviations are made from the table of recommendations, production costs for the non-standard mixture may result in an increase in cost and time delays. The Task Force's original intent was to reduce the number of mix designs used in the metropolitan area in order to gain economy of scale with standard mixes.

Other Recommendations

Although beyond the scope of the Task Force objectives, other related topics surfaced and were addressed. The Task Force recommends that the following actions be considered:

1. Quality Assurance/Quality Control Specifications - It is recommended that QA/QC specifications be considered to promote construction quality control. A statistical approach to quantify the quality level and deviation from means should be used. These specifications should include incentive payments to the contractor for exceeding standard construction specifications as well as the traditional penalty clauses. Training on the use and interpretation of control charts along with proper testing and inspection procedures should be developed. It is also recommended that the local agencies establish a standard "location" for mix sampling.
2. Round Robin testing of asphalt mixture samples should be conducted by local highway agencies and public works departments. Such a program could be developed to insure consistency in sampling and testing among agency technicians as well as verification of proper equipment operation. Agencies should also be involved in a metro-wide technician training program.
3. Historical information should be developed and maintained for long term project pavement performance. The data base should include pavement distress along with good traffic data.

4. As new asphalt pavement mix design and testing procedures (Laboratory Manual of TEST PROCEDURES) are adopted by the Colorado DOT, this information should be submitted to Metropolitan Government Pavement Engineers Council. Distribution could then be made to its members for their consideration, and if appropriate, adoption of these changes should be made on a metro area wide basis.
5. The state-of-the-art technology developed by SHRP is currently being presented in the Asphalt Institute training programs held in Lexington, KY. The SUPERPAVE™ asphalt binder and mix design procedures presented provide training for quality in asphalt paving material design and handling. Colorado DOT is currently sending engineers and technicians to this free training program. It is the Task Force recommendation that personnel from local agencies attend, beginning with the city of Denver.
6. Although a construction topic, pavement smoothness (ride) should be included in the asphalt pavement performance test properties. Colorado DOT is currently developing specifications for this topic. When these specifications are pilot tested, evaluated, and become a standard they should be adopted, as appropriate, by the Metropolitan Government Pavement Engineers Council.
7. Publicity and marketing of these and subsequent Task Force recommendations should be made on a area-wide basis. It is important to keep all local agencies informed as to the state-of-the-practice on a continuing basis.
8. The Metropolitan Government Pavement Engineers Council may wish to retain the Asphalt Pavement Mix Design Task Force on an as-needed basis. As new technologies and changes become available they could then be considered and recommended for adoption by the Council.
9. Included in the references to this report are technical publications that refer to state-of-the-art design and testing procedures for asphalt pavements. These procedures should be available to and used by the local highway agencies and public works departments.
10. As volummetric concepts and Voids in the Mineral Aggregate (VMA) concepts are researched and adopted, they should be considered by the Task Force.
11. Task Forces should be established by the DMGPEC to address issues related to pavement management, pavement design, training, technician certification, and other topics. The objective should be interagency consistency, communication, and cooperative efforts.

TABLE A
DENVER AREA MIX DESIGN
RECOMMENDED HBP DESIGN PROPERTIES

Nominal Size Grading	1/2" CX	3/4" C	3/4" Q	1" G
Gradation				
1 1/2"				100
1"		100	100	90-100
3/4"	100	90-100	90-100	63-85
1/2"	90-100	70-89	89	46-78
3/8"	74-89	60-88	-	-
#4	50-78	44-72	(49-59) ¹	22-54
#8	32-64	30-62	(34-44)	13-47
#16	-	-	(23-33)	-
#30	12-38	12-38	(15-25)	4-26
#50	12-30	(SUPERPAVE™)	(11-18)	-
#200	3-7	3-7	3-7	1-7
Asphalt Type	AC-10	AC-10	AC-10	AC-10
Air Voids ²	3-4-5	3-4-5	3-4-5	3-4-5
VMA (min.) ²	13-14-15	12-13-14	12-13-14	11-12-13
Voids Filled,%	65-75	65-75	65-75	65-75
% RAP	15	20	20	20
% Lime ³	1	1	1	1
% Fract. Faces ⁴	60	60	60 (+4→80)	60 (+4→80)
T.G. Pressure ⁵	50/50/75/75/100 ⁶	(Same)	150	N/A
Hveem Stability	33/33/39/39/42	(Same)	40	N/A
Marshall Stability ⁷	1500/2000	1500/2000	N/A	1500/2000 ⁸
Lottman	>80	>80	>80	>80

NOTES:

- ¹ - (Forbidden Zone To Be Avoided)
- ² - Air Voids/VMA Relationships Listed
- ³ - With Moisture @ 3% SSD
- ⁴ - Particles (+4) With A Minimum Of Two Fractured Faces. (70% on Freeways)
- ⁵ - Texas Gyrotory End Point Pressure
- ⁶ - Functional Class: Residential/Collector/Arterial/Major Arterial/Freeway
- ⁷ - 50/75 Blow Marshall
- ⁸ - Use Stone Correction

TABLE A
DENVER AREA MIX DESIGN
RECOMMENDED HBP DESIGN PROPERTIES

SUPPLEMENTAL MIX DESIGN NOTES:

- A. Colorado DOT Grading C and CX are Standard Mixes used on a statewide basis.
- B. The Grading Q mix can be made with any nominal size or top size. The gapping philosophy helps to insure avoiding a tender (rutting/unstable) mix by minimizing fine sand relative to all sand in the mix. Gradations on the fine side of the maximum density line are typically very tight in appearance and possibly less permeable to water infiltration than gap graded mixes. The mix gradation made away from the maximum density line is typically high in VMA resulting in a low probability of rutting.
- C. The Grading G mix should be relatively cost effective with economic savings from less pit/quarry crushing cost. This mix should be topped with a wearing course of 1/2" or 3/4" nominal size mix. As a caution, this mix can trap water and subsequently strip if left without a wearing course during periods of precipitation or construction runoff water infiltration.
- D. Mix thickness should be, as a minimum, three times the nominal size or at least two times the top size of the mix. Greater thickness are recommended to minimize construction/paver segregation. Hand raking should be avoided except for tight areas. Large sized aggregate mixes will segregate more than small size aggregate mixes.

Summary

1. Table A lists the recommended asphalt pavement mix design specifications to be used for standard paving projects in the Denver Metropolitan area. These specifications should result in quality paving materials while providing a cost-effective value.
2. It may be necessary to deviate from the standard recommendations on a project by project basis. This will be the case when "specialty" mixes are necessary to provide performance to address a specific need. Downscoping may also be necessary on some projects. However, the benefit/costs of these designs may not be optimized.
3. In addition to the factors listed in Table A, additional general specifications recommended are:

Natural Fines:	<20%
Percent # 200:	3-6% without lime
	3-7% with lime
	Production tolerances $\pm 2\%$
L.A. Abrasion:	<40
Sand Equiv. :	>45

4. Other factors should be included in the mix design recommendations as research and pilot testing provides acceptable specifications. These factors include:

QA/QC Specifications
SUPERPAVE™ Performance Factors and Training
Pavement Smoothness
5. The Metropolitan Government Pavement Engineers Council should insure area wide distribution of these recommendations and future Task Force findings as appropriate. Other quality issues pertaining to asphalt pavement should be pursued by the Council including design, historical data collection, training and certification, and publicity.

APPENDIX

**FLEXIBLE PAVEMENT
EVALUATION CHECKLIST**

PROJECT NO. 1, Denver LOCATION Alameda, Grant to Univ.
CONTRACTOR Brannan CONST.DATE. 1991-1992 FACILITY Urban Arterial
DISTRESS EVALUATION SURVEY

Type	Severity	Approx. %
Alligator Cracking	None	
Bleeding/Flushing	None	
Long. Cracking	Slight @ Joints	Subgrade Problems
Trans. Cracking	Slight @ Joints	
Raveling	Const. Related Segregation	5 %
Rutting	None	
Shoving	None	

RECOMMENDED MIX DESIGN CHANGES

Item	As Const.	Comments (+/-)
Gradation	1" (Gr Q) ¹	Lack of sand (#4-#50) in tests out of spec. 47% w/1+ sieve out of spec.
% Frac. Faces	96%	
% RAP	None	
Asphalt Content	4.4%	
Asphalt Viscosity	AC-10P	
Lime	None	
Other Additives	SPS (Koch)	
Stability	46.4 (Spec - 50)	
Lottman	65	75% of tests low
Other:		

General Comments: Plans copied and handed out

3.5% Avg. air voids (50% low), 12.0 Avg. VMA (28% low)

¹ West half of project constructed with CDOT SHRP Fine gradation and polymer added. Not included in evaluation.

**FLEXIBLE PAVEMENT
EVALUATION CHECKLIST**

PROJECT NO. 2, Aurora LOCATION Chambers, Colfax to Smith Rd.
CONTRACTOR Seigrist CONST. DATE 1986 FACILITY Industrial

DISTRESS EVALUATION SURVEY

Type	Severity	Approx. %
Alligator Cracking	Isolated Med	2% along curb
Bleeding/Flushing	None	
Long. Cracking	Medium	10 %
Trans. Cracking	Medium	5 %
Raveling	None	
Rutting	1/2" in heavy traffic lane only	
Shoving		
Other:		

RECOMMENDED MIX DESIGN CHANGES

Item	As Const.	Comments (+/-)
Gradation	Gr. C (E)	
% Frac. Faces	75% (1 Face)	
% RAP	None	
Asphalt Content	5.5%	
Asphalt Viscosity	AC-10	OK
Lime	None	
Other Additives	None	
Stab., Marshall	2129	
Lottman		
Other:		

General Comments: Good Performance for age _____

**FLEXIBLE PAVEMENT
EVALUATION CHECKLIST**

PROJECT NO. 3, CDOT LOCATION I70, I225-Quebec

Project CY 01-0070-25

CONTRACTOR Asphalt Paving CONST.DATE. 1990 FACILITY Interstate

DISTRESS EVALUATION SURVEY

Type	Severity	Approx. %
Alligator Cracking	None	
Bleeding/Flushing	None	
Long. Cracking	Joint, Between Lanes 2 & 3	
Trans. Cracking	Minor	
Raveling	None	
Rutting	Minor	
Shoving	None	
Other:		

RECOMMENDED MIX DESIGN CHANGES

Item	As Const.	Comments (+/-)
Gradation	Gr C	
% Frac. Faces	>60	
% RAP	15%	
Asphalt Content	5.8	
Asphalt Viscosity	AC - 10	Conoco AC-10F
Lime	No	
Other Additives	0.5%	Pave Bond Special
Stability	34	Range: 28-43
Lottman	80	Range: 44-105
Other:		

General Comments: _____

**FLEXIBLE PAVEMENT
EVALUATION CHECKLIST**

PROJECT NO. 4, Aurora LOCATION 17th, W/o Peoria to Dayton
CONTRACTOR West. Paving CONST.DATE. 1990 FACILITY City Street

DISTRESS EVALUATION SURVEY

Type	Severity	Approx. %
Alligator Cracking	None	
Bleeding/Flushing	None	
Long. Cracking	None	
Trans. Cracking	Medium	5 %
Raveling	None	
Rutting	None	
Shoving	None	
Other:		

RECOMMENDED MIX DESIGN CHANGES

Item	As Const.	Comments (+/-)
Gradation	Gr. CX	
% Frac. Faces		
% RAP		
Asphalt Content	?	
Asphalt Viscosity		
Lime	None	
Other Additives	0.5% Pave Bond	
Stability	50 blow Marshall	
Lottman		
Other:		

**FLEXIBLE PAVEMENT
EVALUATION CHECKLIST**

PROJECT NO. 5, Aurora LOCATION Quincy, Reservoir to Gun Club Rd.
CONTRACTOR Asphalt Paving CONST.DATE. 1987 FACILITY Rural

DISTRESS EVALUATION SURVEY

Type	Severity	Approx. %
Alligator Cracking	None	
Bleeding/Flushing	None	
Long. Cracking	Isolated Minor,	2%, Eastbound
Trans. Cracking	Minor, Thermal	1%
Raveling	Isolated Minor	2%, Const. Rel
Rutting	None	
Shoving	None	
Other:		

RECOMMENDED MIX DESIGN CHANGES

Item	As Const.	Comments (+/-)
Gradation	CX (EX)	
% Frac. Faces	50%	
% RAP	None	
Asphalt Content	5.2%	
Asphalt Viscosity		
Lime	None	
Other Additives	0.5.2%	Pave Bond Anti-strip
Stability		
Lottman		
Other:		

General

Comments: _____

**FLEXIBLE PAVEMENT
EVALUATION CHECKLIST**

PROJECT NO. 6, Aurora LOCATION Gun Club Road, N/o Smokey Hill Rd.
CONTRACTOR Brannan CONST.DATE. _____ FACILITY Rural

DISTRESS EVALUATION SURVEY

Type	Severity	Approx. %
Alligator Cracking	None	
Bleeding/Flushing	None	
Long. Cracking	None	
Trans. Cracking	None	
Raveling		
Rutting	Minor	1/4 to 3/8"
Shoving	None	
Other:		

RECOMMENDED MIX DESIGN CHANGES

Item	As Const.	Comments (+/-)
Gradation	G with 1/2" CX	
% Frac. Faces		
% RAP		
Asphalt Content		OK
Asphalt Viscosity		
Lime	None	
Other Additives		
Stability		
Lottman		
Other:		

General Comments: Good for low truck traffic

**FLEXIBLE PAVEMENT
EVALUATION CHECKLIST**

PROJECT NO. 7, Aurora LOCATION Ensenada Way, N/o Flanders Way
CONTRACTOR West. Paving CONST.DATE 1991 FACILITY Residential

DISTRESS EVALUATION SURVEY

Type	Severity	Approx. %
Alligator Cracking	None	
Bleeding/Flushing	None	
Long. Cracking	None	
Trans. Cracking	None	
Raveling	Minor, Const. Related	5%
Rutting	None	
Shoving	None	
Other:		

RECOMMENDED MIX DESIGN CHANGES

Item	As Const.	Comments (+/-)
Gradation	CX	OK
% Frac. Faces	50% 2 Faces	
% RAP	None	
Asphalt Content	5.6 %	
Asphalt Viscosity	AC-10	
Lime	None	
Other Additives	0.5% Pave Bond	
Stab. Marshall	3000	
Lottman		
Other:		

General

Comments: _____

**FLEXIBLE PAVEMENT
EVALUATION CHECKLIST**

PROJECT NO. 8, CDOT LOCATION Tower Rd. N/o 88th Ave
 Project CY 12-0044-05
 CONTRACTOR BROC CONST.DATE 1993 FACILITY Rural/Airport Access

DISTRESS EVALUATION SURVEY

Type	Severity	Approx. %
Alligator Cracking	None	
Bleeding/Flushing	None	
Long. Cracking	None	
Trans. Cracking	Medium, Reflective	5%, 30-150' spacing
Raveling	none	
Rutting	none	
Shoving	none	
Other:		

RECOMMENDED MIX DESIGN CHANGES

Item	As Const.	Comments (+/-)
Gradation	Gr C	
% Frac. Faces	>70	OK
% RAP	15% - 0%	
Asphalt Content	4.7 - 4.8	OK
Asphalt Viscosity	AC-10	Sinclair
Lime	1%	OK
Other Additives	None	
Stability	46	
Lottman	101	
Other:		

General Comments: _____

**FLEXIBLE PAVEMENT
EVALUATION CHECKLIST**

PROJECT NO. 12, CDOT LOCATION Leetsdale Dr @ Miss.
 Project HOS 0006(56) (#6-34)
 CONTRACTOR Seigrist CONST.DATE 11/91 FACILITY Urban

DISTRESS EVALUATION SURVEY

Type	Severity	Approx. %
Alligator Cracking	None	
Bleeding/Flushing	None	
Long. Cracking	None	
Trans. Cracking	None	
Raveling	Minor	5%, Const. Segregation
Rutting	None	
Shoving	None	
Other:		

RECOMMENDED MIX DESIGN CHANGES

Item	As Const.	Comments (+/-)
Gradation	GR C	OK
% Frac. Faces	>60	
% RAP	11%	
Asphalt Content	4.4%	Increase by 0.7 %
Asphalt Viscosity	AC-10	Sinclair
Lime	1%	
Other Additives		Pave Bond Special
Stability	48	
Lottman	113	
Other:		

General Comments: Original Texas Gyrotory Mix Design

**FLEXIBLE PAVEMENT
EVALUATION CHECKLIST**

PROJECT NO. 13, CDOT LOCATION Colo. Blvd, Louisiana to Hampden
Project CX 01-0002-45
CONTRACTOR BROC CONST.DATE. 1991 FACILITY Commercial

DISTRESS EVALUATION SURVEY

Type	Severity	Approx. %
Alligator Cracking	None	
Bleeding/Flushing	Minor	Wheelpath
Long. Cracking	Severe Reflect.	20%
Trans. Cracking	Const. Joints	2%
Raveling	Very Minor	2% Between Wheelpaths
Rutting	Very Minor*	1%
Shoving	None	
Other:		

RECOMMENDED MIX DESIGN CHANGES

Item	As Const.	Comments (+/-)
Gradation	Gr CX	OK
% Frac. Faces	>60	OK
% RAP	11%	
Asphalt Content	4.4	Increase 0.5 to 0.8%
Asphalt Viscosity	AC-10	Sinclair
Lime	1%	OK
Other Additives	None	
Stability	41	
Lottman	98	OK
Other:		

General Comments: * - Probably reflective even through milled prior to overlay

**FLEXIBLE PAVEMENT
EVALUATION CHECKLIST**

PROJECT NO. 14, Denver LOCATION Monoco, n/o Colfax
CONTRACTOR Brannan CONST.DATE. 1992 FACILITY Urban

DISTRESS EVALUATION SURVEY

Type	Severity	Approx. %
Alligator Cracking	None	
Bleeding/Flushing	None	
Long. Cracking	None	
Trans. Cracking	None	
Raveling	None	
Rutting	None	
Shoving	None	
Other:		

RECOMMENDED MIX DESIGN CHANGES

Item	As Const.	Comments (+/-)
Gradation	SHRP Fine	
% Frac. Faces	Unknown	
% RAP	None	
Asphalt Content	4.8	All in Specs.
Asphalt Viscosity	10P	
Lime	1%	OK
Other Additives	SPS Polymer Mod.	
Stability	44 (Spec 45)	77% of tests low
Lottman	85%	
Other:	Voids 2.6% VMA 13.1	86% Low 57% on Low

General Comments: Good looking job.

**FLEXIBLE PAVEMENT
EVALUATION CHECKLIST**

PROJECT NO. 15, Denver LOCATION 6th Ave E/o Colo Blvd.
CONTRACTOR Western Paving CONST.DATE. FACILITY Arterial

DISTRESS EVALUATION SURVEY

Type	Severity	Approx. %
Alligator Cracking	None	
Bleeding/Flushing	None	
Long. Cracking	None	
Trans. Cracking	Medium	5 %
Raveling	None	
Rutting	None	
Shoving	None	
Other:		

RECOMMENDED MIX DESIGN CHANGES

Item	As Const.	Comments (+/-)
Gradation	(Gr.Q)	1" Nom., 1-1/2" Top
% Frac. Faces	100%	
% RAP	None	
Asphalt Content	4.2 - 4.9	Opt. = 4.2
Asphalt Viscosity	20P	
Lime	None	
Other Additives	None	
Stability	35-45 45-55	(Lab 1) (Lab 2)
Lottman	90+	
Other: Air Voids VMA	4.0 11.9 - 13.5	

Colorado DOT Project Gradations

<u>Sieve</u>	<u>Design</u> <u>% Passing</u>	<u>Project</u> <u>% Passing</u>
--------------	-----------------------------------	------------------------------------

Project No.3, I70, I225 to Quebec

3/4	100	100
1/2	87	88
3/8	72	79
#4	57	63
#8	45	48
#16		38
#30	28	28
#50		18
#100		12
#200	8.0	7.8

Project No.8, Tower Rd., N/o 88th Ave.

3/4	100	100
1/2	86	89
3/8	74	75
#4	56	60
#8	48	50
#16		37
#30	23	26
#50		16
#100		9
#200	5.0	6.0

Colorado DOT Project Gradations (Cont.)

<u>Sieve</u>	<u>Design</u> <u>% Passing</u>	<u>Project</u> <u>% Passing</u>
--------------	-----------------------------------	------------------------------------

Project No.12, Mississippi at Leetsdale

3/4	100	100
1/2	87	89
3/8	78	74
#4	55	54
#8	39	35
#16		25
#30	20	18
#50		12
#100		8
#200	6.0	5.6

Project No.13, Colo. Blvd., Louisiana to Hampden

1/2	100	100
3/8	87	91
#4	58	58
#8	45	44
#16		32
#30	21	23
#50		16
#100		11
#200	7.0	7.2

REFERENCES

- Aschenbrener, T. (1993), "Determining Optimum Asphalt Content with the Texas Gyratory Compactor," Colorado Department of Transportation, Report No. CDOT-DTD-R-93-23
- Aschenbrener, T. and N. Far (1994), "Influence of Compaction Temperature and Anti-Stripping Treatment on Results from the Hamburg Wheel-Tracking Device," Colorado Department of Transportation, Report No. CDOT-DTD-R-94-9
- Asphalt Institute, *Mix Design Methods, For Asphalt Concrete and Other Hot-Mix Types*, Manual Series No.2, Sixth Edition
- Asphalt Institute, *The Asphalt Handbook*, Manual Series No.4, 1989 Edition
- Colorado Department of Transportation, *Field Materials Manual* 1994, January 1, 1994
- Colorado Department of Transportation, *Laboratory Manual of TEST PROCEDURES*, 1988