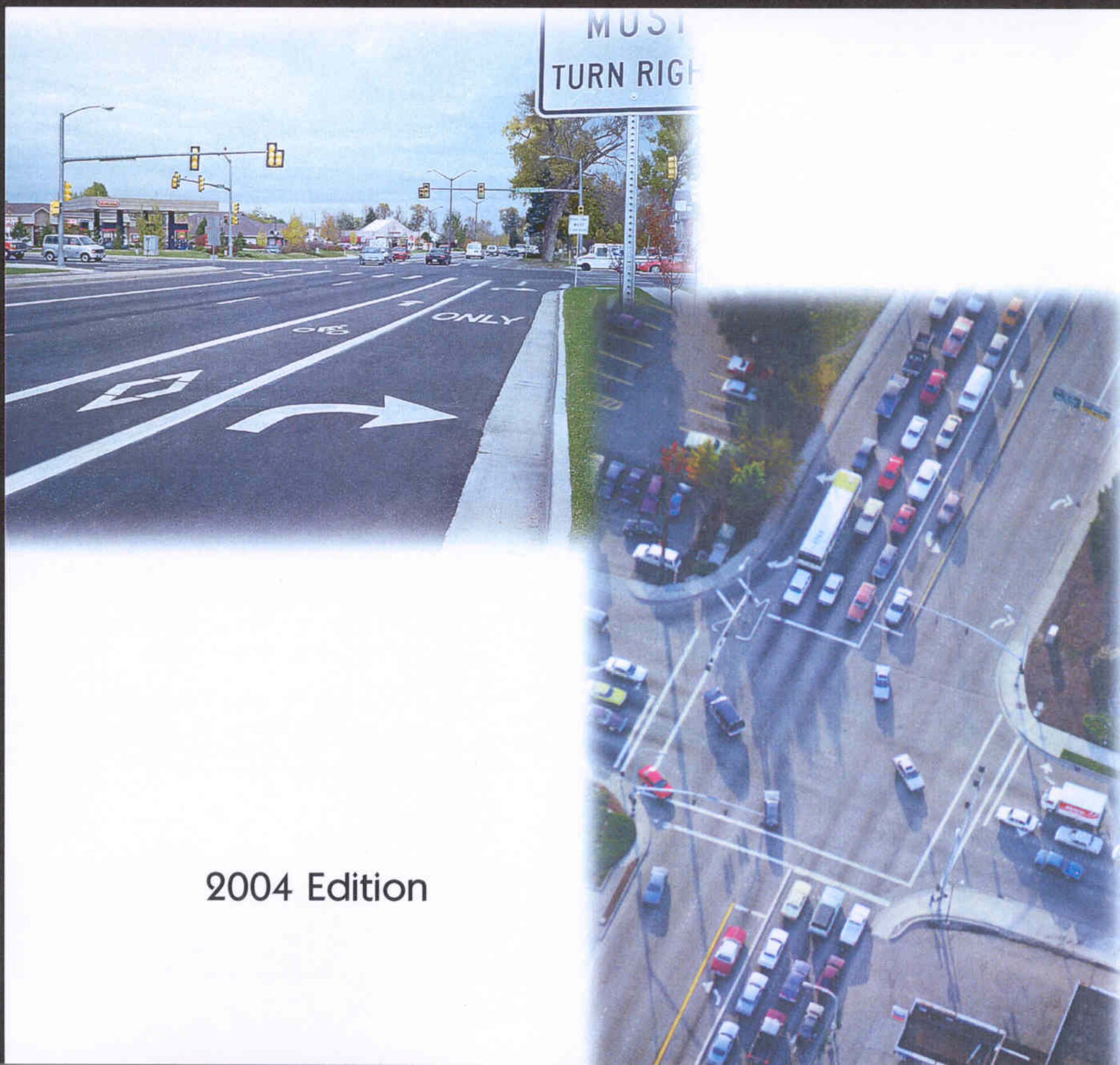
Colorado Asphalt
Pavement Association

A Guideline for Designing High Performance Asphalt Intersections for Colorado Roadways



2004 Edition

Introduction:

The following guide is intended to help the design engineer with designing high performance, high volume asphalt intersections utilizing Superpave asphalt mix technology. While they can be used, different types of pavement materials such as Stone Mastic Asphalt (SMA) are beyond the scope of this design guide. The guide is a compilation of the most recent state-of-the-art technology related to Superpave and asphalt pavement design for high volume intersections.

The traffic analysis procedures are based on current methods, which are under review, both nationally and by the Colorado Department of Transportation. When these procedures are modified, they will be incorporated into a futue edition of the guide.

Recognition should be given to the following organizations for their contribution to the intersection design guide.
- The Colorado Department of Transportation (CDOT)
- The Asphalt Institute
- National Asphalt Pavement Association (NAPA)
- Western Colorado Testing, Inc.

The Challenge:

Hot mix asphalt (HMA) pavement is the paving material of choice for a majority of Colorado roadways. The advantages of reduced cost and less construction delay combined with improved smoothness and ease of maintenance make asphalt pavement a viable solution for all types of roadways. However, in some cases, good performance of asphalt pavement at high traffic volume intersections has not been achieved.

Some mixes that have a history of good performance may not perform well in intersections, climbing lanes, truck weigh stations and other slow-speed areas. Special attention should be focused on high traffic volume intersections to ensure long term pavement performance.

The key to achieving this desired performance is recognizing that these pavements may need to be treated differently than conventional roadways. Specifically, the pavement must be designed and constructed to withstand the more severe conditions. Well-designed, properly constructed HMA intersections provide an economical, long-lasting pavement with minimal disruption.

This document provides design and project scoping information so as to improve the performance of asphalt pavement for high traffic volume intersections. Included is guidance on assessing problems with existing intersections, ensuring structural adequacy, selecting and controlling materials, and tips on proper construction practices.

The Strategy:

Special consideration needs to be given to intersections with heavy truck traffic and high traffic volumes where 30-year traffic volumes are ≥1-3 million ESALs.

DESIGNING A HIGH PERFORMANCE ASPHALT INTERSECTION

Special consideration needs to be given to intersections with heavy truck traffic and high traffic volumes where 30-year traffic volumes are ≥1-3 million ESALs. A standard pavement design is based on fast moving traffic traveling one direction on long stretches of roadway where drainage is usually easy to handle. With high traffic volume intersections, it's necessary to design for slower stop and go traffic, which induces much heavier stresses on the pavement section. Design equivalent single axle loads (ESALs) are greater in intersections because of compounding traffic direction. Also, drainage is often compromised within intersections, leading to saturation of the pavement section and the underlying subgrade.

To avoid performance problems at high traffic volume intersections, the following key strategies should be followed:

- Implementing the correct plan
- Assessing problems with existing intersections
- Ensuring structural accuracy
- Selecting and controlling materials
- Following proper construction practices

This guideline provides design and project scoping information so as to improve the performance of asphalt pavement for high traffic volume intersections.

Implementing the Correct Plan

Determining whether or not to use a high performance HMA intersection design vs. a conventional HMA design should be assessed on a project-by-project basis. Some general rules to consider are:

- When 30-year traffic loading is ≥1-3 million ESALs within an intersection, a high performance intersection design should be used.
- If high traffic volume intersections are within 1/4 mile of each other, the entire roadway should be designed using a high performance intersection design.
- If there are not enough high performance intersections within a project to warrant a high traffic volume intersection design throughout, but the intersections that are within the project are potentially subject to moderate-to-heavy traffic (≥1-3 million ESAL's), they should be blocked out and a high traffic volume intersection design used.
- Acceleration and deceleration lanes should be included as part of the intersection design.
- Sharp turns with slow moving traffic should be included as part of the intersection design.
- When there is two-way traffic, the transition should extend at least 300 linear feet on either side of the intersection.
- When there is one-way traffic, the transition should be at least 300 linear feet on the deceleration side and 100 linear feet on the acceleration side of the intersection.

Assessing Problems with Existing Intersections

A successful intersection rehabilitation project is dependent on proper project scoping. The keys to proper scoping are the following:

- Identifying the problem with the existing intersection,
- Removing enough of the pavement section to encompass all of the problem,
- Designing and reconstructing with a high performance hot mix asphalt mix design especially formulated for high traffic volume intersections.

PERFORMANCE CHARACTERISTICS

The AASHTO Joint Task Force on Rutting (1987) identified four types of rutting:

- **Mechanical Deformation** (or rutting) is the result of insufficient structural capacity. "Alligator Cracking" usually accompanies it. (Figure 1)
- **Plastic Flow** can result for various reasons:
  - High Pavement Temperatures
  - Materials and Mixture Design
    - Rounded aggregate
    - Too much binder and/or filler
    - Insufficient or too high of VMA
  - Asphalt Production

(cont.)

rutting

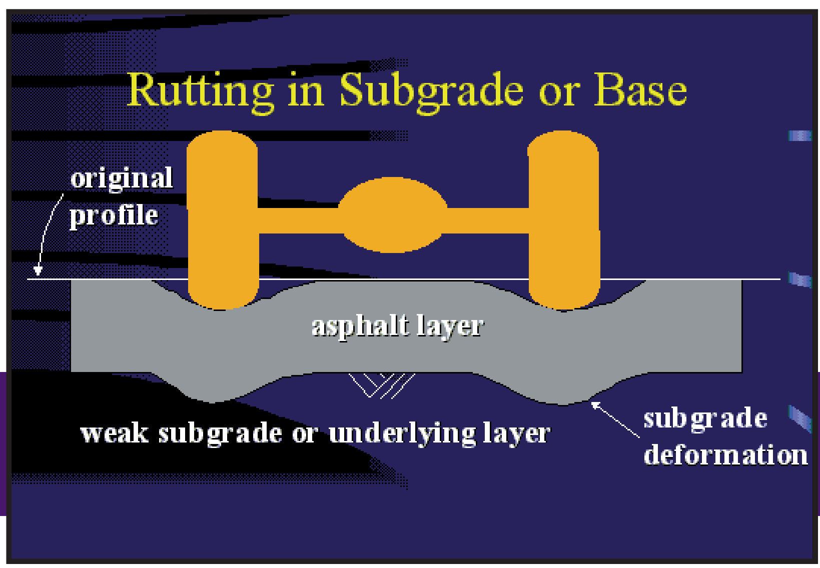


Figure 1: Rutting in the subgrade; a weak subgrade or base will expedite damage in all pavements.

plastic flow

Plastic flow or deformation in the asphalt layer occurs during warm summer months when pavement temperatures are high. At intersections, stopped and slow moving traffic allows exhaust to elevate asphalt surface temperatures even higher. Dripping engine oil and other vehicle fluids are also concentrated at intersections and tend to soften the asphalt. A properly designed mixture with a stiffer asphalt binder and strong aggregate structure will resist plastic deformation of the hot mix asphalt pavement. (Figure 2)

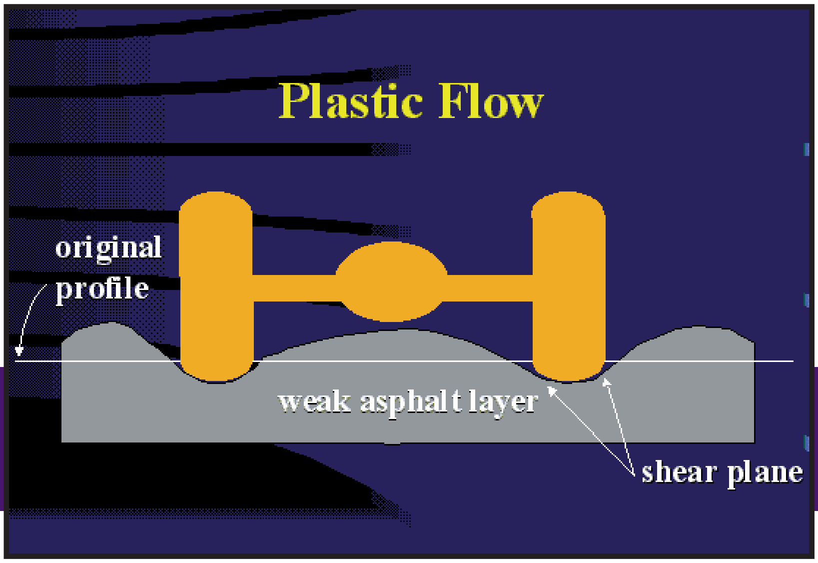


Figure 2: Rutting in the asphalt layer; good quality control in the design and production of asphalt mixtures is crucial.

- **Consolidation** occurs in the wheel paths because of insufficient compaction of the pavement section. A number of factors can contribute to lack of compaction. (Figure 3)
  - Insufficient compaction effort within the lower base layers of the pavement section
  - Too few roller passes during paving
  - Hot Mix Asphalt Material cooling prior to achieving target density
  - High fluid content (asphalt moisture, dust)
  - Too low of an asphalt content - lack of cohesion in the mix
  - Tender Mix - A gradation problem with the mix can make it hard to compact
- **Surface wear** is the result of chains and studded tires wearing away the road surface in winter. Moisture damage or raveling will occur if drainage is not adequate.

consolidation

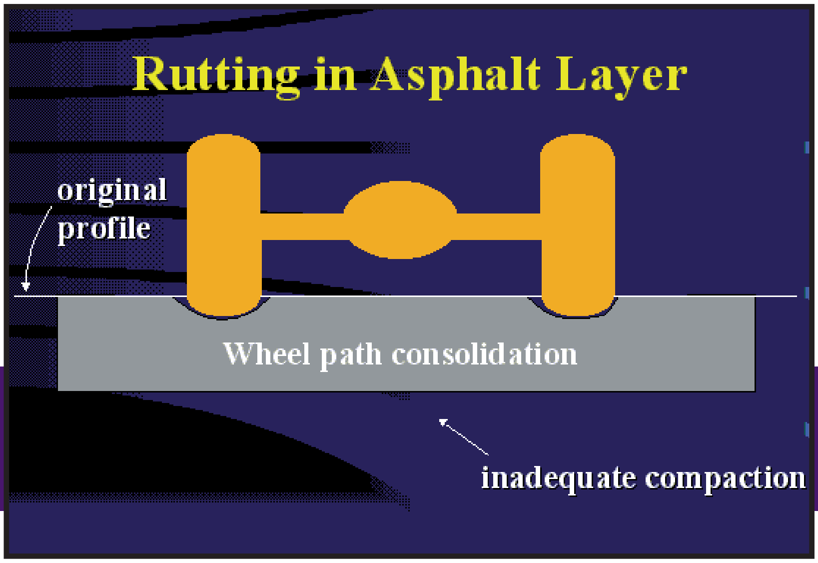


Figure 3: Consolidation in the wheel paths; proper compaction procedures and techniques will ensure that the target density is achieved.

Ensuring Structural Adequacy

To ensure long life performance, the pavement section for intersections must have adequate thickness to support the slow moving or stopped traffic induced loads. Whether new or existing, the thickness of each component of the section must provide structural integrity and be sufficient so that, as a combined unit or pavement section, it will carry the anticipated loads and higher stresses resulting from slower moving traffic.

Key factors to consider when ensuring structural adequacy:

- Subgrade strength
- Frost depth
- Subbase and base thickness
- Asphalt thickness
- Traffic type and loading
- Drainage

SUBGRADE STRENGTH

For hot mix asphalt pavement in Colorado the subgrade strength is measured by one of the following methods:

- Colorado Procedure CP-L 3101 "Resistance R-Value and Expansion Pressure of Compacted Soils"
- ASTM D 1883 - 94 "Standard Test Method For CBR (California Bearing Ratio) of Laboratory Compacted Soils"
- ASTM D 4429 - 93 "Standard Test Method For CBR (California Bearing Ratio) of Soils in Place"

Subgrade strength is a function of soil type, density and moisture content. A given soil type with varying density and/or moisture content will perform quite differently in its ability to support the intended pavement section and traffic loads. Laboratory prepared CBR and R-Values are, by standard test procedure, performed at or near optimum moisture contents and compacted densities that reflect man-made fills placed under controlled, closely monitored conditions.

In-place, or in-situ, soils are often much less dense and more saturated. The "true" in-place strength values of the subgrade are often much lower than laboratory measured strength values. Accordingly, ASTM D 4429-93 "Standard Test Method For CBR (California Bearing Ratio) of Soils in Place" may be used as a method to measure the strength of the in-place subgrade soils. The Colorado Department of Transportation uses Hveem stabilometer equipment to measure strength properties of soils and bases. Section 5.4.2.E. of the Pavement Design Manual describes the evaluation of this procedure for determining Resilient Modulus.

FROST DEPTH

In Colorado, frost depth needs to be considered when determining pavement thickness. Whenever the frost depth is deeper than the calculated pavement section and the subgrade soils are susceptible to frost heave, special consideration should be given to the potential effects of the frost.

SUBBASE AND BASE THICKNESS

Thickness of subbase and base should be determined based on assigned strength coefficients for each material. Actual thickness determination should be calculated. Minimum thickness of an individual base layer should be at least 4 inches but not less than 2 times the nominal maximum particle size of the aggregate.

If the underlying subgrade soils are clays and have swell potential, consideration should be given to removing at least two feet of the subgrade and placing a pavement section of subbase, base and hot mix asphalt.

ASPHALT THICKNESS

The asphalt thickness should also be determined based on assigned strength coefficients. The minimum asphalt thickness of an individual lift of hot mix asphalt should be at least three times (3:1 ratio) the maximum nominal particle size of the aggregate in the mix. The only exception to the 3:1 ratio minimum lift thickness would be for surface treatments such as various seal coats, which can vary based on the individual application.

(cont.)

The use of recycled asphalt pavement (RAP) in the pavement section should be considered. As an example, if it is not convenient to use milled asphalt as RAP in the asphalt mix, it can be incorporated into the subbase and base layers of the pavement section. Milled asphalt mixed with base is stronger than base only. Milled asphalt placed as a layer by itself is even stronger.

TRAFFIC TYPE AND LOADING

Accurate traffic counts of existing traffic and/or realistic traffic projections for future growth and new construction are necessary to ensure that the pavement section is designed properly. ***Cross traffic at intersections needs to be accounted for as part of the traffic count projection.*** The percentage of 18 kip single axle trucks also needs to be determined. Vehicle classifications, by type, should be identified in order to determine 18kip equivalent loads (ESALs).

The impact of construction equipment during early phases of a new subdivision or project should be considered. Truck traffic hauling building materials during the development of a subdivision or project can have a greater impact on design than past construction or the “built out” condition.

Cross traffic at intersections needs to be accounted for as part of the traffic count projection.

DRAINAGE

Adequate subsurface and surface drainage is necessary to assure the structural integrity of hot mix asphalt pavement sections. At intersections, surface drainage is often compromised, leading to ponding of water, which results in early surface deterioration and eventual loss of strength within the pavement section.

In Colorado, snow removal can be a problem, especially near intersections. If snow is left piled at the edge of a roadway or street side drainage, curb flow lines, culverts, and cross pans become obstructed, forcing runoff to pond on the paved surface, or, worse yet, at the pavement interface with the curb or edge of the pavement. When this happens, water infiltrates downward saturating the pavement section causing it to lose strength. Maintaining flow lines in ditches, and into drop inlets and culverts is necessary so that water doesn’t become concentrated at intersections.

Irrigation of planters and landscape areas often contribute to saturation of the pavement section and subgrade. Such areas should not be used or they should be specially designed with subdrains to keep water out of the pavement section.

SELECTING AND CONTROLLING MATERIALS

The key elements of a properly designed intersection include various combinations of quality materials.

- Modified subgrade
- Geo-synthetic fabrics and mats
- Aggregate subbase
- Aggregate base
- Drainage systems
- Recycled construction materials
- Hot Mix Asphalt

MODIFIED SUBGRADE

While not covered in this technical report, subgrade modification techniques to improve the strength of the subgrade are often beneficial and recommended in special cases. Lime, flyash, and cement are types of materials used for stabilization, depending on the subgrade soil type. A qualified geotechnical consultant should be retained to help with a potential subgrade modification design.

GEO-SYNTHETIC FABRICS AND MATS

Geo-synthetic fabrics and mats can be used as reinforcement in a variety of ways within and below the pavement section. Any time poor or marginally acceptable in-situ soils are encountered, geo-synthetic fabrics and mats should be considered. Technical representatives for individual brand materials are available to help in the selection of the most appropriate product.

Separation fabrics used to separate fine grain silts and clays from open-graded drainage mats and subbase/base materials are an especially valuable and cost effective application. Without them, a soft subgrade could inundate the more open void spaces of drainage mats and base courses, thereby, decreasing their strength and ability to drain.

AGGREGATE SUBBASE

Aggregate Subbase courses should conform to Section 304 "Aggregate Base Course" and Section 703.03 "Aggregate For Bases" Class 1 or 2 of the Colorado Department of Transportation Standard Specifications for Road and Bridge Construction, 1999 Edition.

AGGREGATE BASE

Aggregate Base Course should conform to Section 304 "Aggregate Base Course" and Section 703.03 "Aggregate for Bases" Class 6 of the Colorado Department of Transportation Standard Specifications for Road and Bridge Construction, latest revision thereof.

DRAINAGE SYSTEMS

A well drained pavement section is required to maintain the strength coefficients assigned to individual components of a hot mix asphalt pavement section. Edge drains, cross drains, and drainage layers all must tie into a collection system or some means to carry collected water away from intersections and the pavement section. Installing drainage systems that collect and impound water rather than diverting it away from the pavement section should never be allowed.

RECYCLED CONSTRUCTION MATERIALS

During rehabilitation of intersections, it is often a cost savings to utilize certain construction materials that have been removed by placing these materials back into the pavement section. Such things as pulverized concrete, milled asphalt, and existing bases can sometimes be re-incorporated into subbase and base layers with or without additional enhancement. Doing so can result in a cost savings to the project without sacrificing the structural integrity of the pavement section. Any such inclusion of these materials should be based on assigning appropriate strength coefficients for their individual use.

The Colorado Department of Transportation allows the use of reclaimed asphalt pavement. Reclaimed asphalt pavement (RAP) is allowed in hot mix asphalt (HMA)* up to a maximum of 25% provided all specifications for HMA are met. The use of RAP in intersection design should be permitted in a similar manner.

**with the exception of the top 4" of new or reconstructed pavements*

HOT MIX ASPHALT (HMA)

HMA is composed of aggregates with an asphalt binder and, when required, certain anti-stripping additives. As a result of the Strategic Highway Research Program (SHRP), now commonly referred to as "Superpave", asphalt binders are now classified based on their performance at both hot and cold temperatures. By carefully selecting quality aggregates and the correct Superpave Performance Graded (PG) asphalt binder, it is possible to produce high quality hot mix asphalt for a wide variety of climactic conditions in Colorado.

Non-Modified Binders		Modified Binders	
Previous Grade	PG Grade	Previous Grade	PG Grade
AC-5	–	–	PG 58-34
AC-10	PG 58-28	AC-20R	PG 64-28
AC-20	PG 64-22	–	–
–	–	–	PG 76-28

For high traffic volume intersections, the asphalt binder industry in Colorado recommends PG 76-28 binder be used for all lifts of intersection paving throughout all climactic regions of Colorado.

Performance Graded (PG) Binders have two numbers in their designation such as PG 58-34. Both numbers describe the pavement temperatures in Celsius at which the pavement must perform. The first number (58 in the example) is the high temperature standard grade for the pavement, and the second number (minus 34 in the example) is the low temperature standard grade.

PG graded asphalt binders available in Colorado can be compared to previous graded binders as illustrated in the cart on upper right.

The CDOT grade bumping procedure for "slow moving traffic" should be used on State projects as described in the Pavement Design Manual, Table A-8. In determining the use of polymer modified binders at an intersection, minimum quantities need to be examined.

For high traffic volume intersections, the asphalt binder industry in Colorado recommends PG 76-28 binder be used for all lifts of intersection paving throughout all climactic regions of Colorado.

The asphalt mix design or job mix formula should be based on Superpave technology. The compaction effort, or number of gyrations of compaction at Design (N_{Design}), for the Superpave compactor is varied to allow for different levels of compaction for different traffic loading (ESALs) and for different environmental categories. The various design gyrations used for Superpave are similar to different blow counts for the Marshall Method of Mix Designs. The highest 7-day average maximum air temperature is used to find the high temperature category. This category is used with the total 18k ESALs to find N_{Design}. The new recommended N_{Design} Table for Superpave shows the number of gyrations required for the Superpave compactor for different ESALs and environmental categories.

It is recommended that for high traffic volume intersections the N_{Design} should be selected based on a traffic level one level higher than would be selected for normal roadway or street design. The compaction effort (number of gyrations) corresponding to the higher level of ESALs should be used for the mix design. Example: Traffic level is determined to be <0.3 million ESALs. Go to 0.3-3 million ESALs (one traffic level higher) in the table and select 75 gyrations N_{Design} for the mix design compaction effort.

To assure high quality and long term performance, it is recommended that a laboratory performance test be conducted on the final mix design. The Hamburg Rut Tester or the Asphalt Pavement Analyzer could be used for this test.

Recommended Superpave Gyratory Design Revolution (N_{Design})				
Total 18k ESALs	High Temperature Category			
	Very Cool	Cool	Moderate	Hot
$<10^5$	50	50	50	50
10^5 to $3x10^5$	50	75	75	75
$3x10^5$ to 10^6	75	75	75	75
10^6 to $3x10^6$	75	75	75	100
$3x10^6$ to 10^7	75	75	100	100
10^7 to $3x10^7$	–	–	100	–
$>3x10^7$	–	–	125	–

It is recommended that for high traffic volume intersections the N_{Design} should be selected based on a traffic level one level higher than would be selected for normal roadway or street design.

High performance hot mix asphalt for intersections require that the aggregate selected for the mix be of high quality. The Aggregate Properties Table provides specification requirements necessary to assure that the hot mix asphalt will perform properly.

Aggregate Properties		
Aggregate Test Property	**Coarse - Retained on #4**	**Fine - Passing #4**
Fine Aggregate Angularity CP 5113 Method A	—	45% Minimum
Two Fractured Faces	80% minimum	—
L.A. Abrasion AASHTO T96	40% maximum	—
Flat & Elongated Pieces (Ratio 3:1) AASHTO M283	10% maximum	—
Sodium Sulfate Soundness AASHTO T104	12% maximum – Combined Course/Fine	
Adherent Coating (Dry Sieving) ASTM D5711	0.5%	45% minimum
Plasticity Index AASHTO T89, T90	—	N.P.

Additionally, the aggregates representing the minus #4 sieve fraction (fines) should have no flat and/or elongated rock slivers (arrowhead shaped). They should be composed entirely of angular, coarse textured, cube shaped particles. Absorptive aggregates (>2% water absorption) should be avoided.

(cont.)

The composite gradation for the aggregate should be in compliance with Table 703-3 “Master Range Table for Hot Bituminous Pavement (Hot Mix Asphalt) of the Colorado Department of Transportation Standard Specifications for Road and Bridge Construction, 1999 Edition:

TABLE 703 Master Range Table for Hot Mix Asphalt Pavement				
	Percent by Weight Passing Square Mesh Sieve			
Sieve Size	Grading SX (½")	Grading S (¾")	Grading SG (1")	Job Mix Tolerances
37.5mm (1½")			100	–
25.0mm (1")	–	100	90-100	±6
19.0mm (3/4")	100	90-100		±6
12.5mm (1/2")	90-100	*	*	±6
9.5mm (3/8")	*	*	*	±6
4.75mm (#4)	*	*	*	±5
2.36mm (#8)	28-58	23-49	19-45	±5
1.18mm (#16)				–
600µm (#30)	*	*	*	±4
300µm (#50)				–
150µm (#100)				–
75µm (#200)	2-10	2-8	1-7	±2

*These additional Form 43 Screens will initially be established for the Contractor’s Quality Control Testing using values from the AS Used Gradation shown on the Design Mix.

The volumetric properties of the mix design should be as follows:

Air Voids - design air voids of 3.5% to 4.5% with a target of four percent.

Minimum VMA Requirements			
Nominal Maximum Size[1] mm (in.)	Design Air Voids[2]		
	3.5%	4.0%	4.5%
37.5 (1-1/2)	11.2	11.7	12.2
25.0 (1)	12.2	12.7	13.2
19.0 (3/4)	13.2	13.7	14.2
12.5 (1/2)	14.2	14.7	15.2
9.5 (3/8)	15.2	15.7	16.2

[1] The Nominal Maximum size is defined as one size larger than the first sieve to retain more than 10%.

[2] Interpolate specified VMA values for design air voids between those listed

Voids in the Mineral Aggregate (VMA) requirements.

VFA Criteria	
ESALs (millions)	Design VFA, %
<0.3	70-80
0.3-3	65-80
3-30	65-75
>30	65-75

Voids Filled with Asphalt (VFA) at 4% air voids, based on traffic level.

Construction Practices

A final and very important strategy to consider when rehabilitating or constructing a high performance intersection is following proper construction practices. The quality of a completed project is not only dependent on proper design and good quality materials, but also on using quality workmanship. Here are several issues to address to ensure quality workmanship.

- Process Control Plan
- Compliance with Project Specifications
- Utilities
- Production and Placement

PROCESS CONTROL PLAN

When rehabilitating intersections or constructing new intersections, special consideration should be given to details and to practicing proper construction techniques. The contractor should submit a "Process Control Plan" containing Quality Control, Quality Acceptance and Independent Assurance Testing schedules. All details of construction, including control of materials and their transportation and placement, need to be covered. A complete schedule of construction activities should be included. Quality Control, Quality Acceptance, and Independent Assurance Testing should be defined and coordinated so that all parties work together for the benefit of the project.

COMPLIANCE WITH PROJECT SPECIFICATIONS

Materials delivered to the intersection construction project should be sampled and tested before placement to make sure they are of high quality and in compliance with project specifications. Additional sampling and testing should be performed again during placement and upon completion of each phase to ensure that they are still in compliance and have been placed or installed properly. Special attention should be given to controlling grade for each portion of the pavement section. Target densities should be met for all of the various materials provided.

UTILITIES

Whether it be intersection rehabilitation or new construction, a utility study should be performed to determine if utilities being proposed, or that are already installed, are adequate in size to handle the projected growth within their service area. It should be verified that they are adequately sized and that they have been installed properly, and that utility trenches have been backfilled and compacted properly.

PRODUCTION AND PLACEMENT

At the start of paving, the volumetric properties of the plant produced material should be re-evaluated. Adjustments should be made to the plant produced material as necessary, so that all of the volumetric criteria remain within the specification limits required for the Job Mix Formula (Mix Design). If "fine tuning" of the plant produced mix does not allow for the required volumetric properties, a new Job Mix Formula should be required.

During Hot Mix Asphalt paving, it is vital that the contractor practice proper construction techniques and pay attention to details.

- ▲ Achieve target density. (Most Important)
- ▲ Avoid the use of diesel fuel in truckbeds.
- ▲ Do not overheat the mixture.
- ▲ Thoroughly clean milled areas.
- ▲ Avoid segregation during production, transportation and placement.
- ▲ Proper joint construction is important to prevent the entrance of water.

CONSTRUCTABLILTY REVIEW

In order to have a successful intersection project, the construction sequencing needs to be addressed. It is recommended that a constructability review be held for complex or high performance intersections. This should include the owner and industry representatives so that a wide variety of options on the most effective phasing can be obtained.

As the owner/agency nears the point where the project plans are nearing completion, it is beneficial for several paving contractors from the area to meet and discuss the project logistics in an open, round table discussion. Issues that can be discussed include availability and delivery of materials planned for the mix design; construction schedule, sequencing, or phasing; coordination with local residents or businesses; environmental concerns; and other issues of mutual interest to the owner and contractor. Quite often these constructability reviews will result in changes that will benefit everyone involved, avoid surprises at the bid letting stage, and frequently result in better bid prices.

REHABILITATION OF EXISTING INTERSECTIONS

Thus far, this guideline provided design information as it pertains to new or the reconstruction of existing intersections. Often, funding is not available for reconstruction of the complete pavement section and a top-down rehabilitation is planned. This is also the case when the underlying pavement sections are performing satisfactorily and are not in need of reconstruction.

Under these circumstances, a good engineering study of the existing intersection pavement structure is necessary to determine the type and extent of rehabilitation needed. An investigation of the intersection site is necessary which includes visual observations of the existing surface distress. However, most importantly, a transverse slab or cores should be taken of the pavement layers for observation in the laboratory and testing to determine material properties including void content, stripping, and others. These cores should be taken strategically throughout the intersection including within and outside the wheelpaths. Surface material should be milled to a depth where the pavement has 3-5% air voids.

It is important to note the distressed sections on the cores so that that thickness, from the top of the pavement surface, is milled and replaced as part of the pavement rehabilitation process. This is especially the case when the air void content in the upper asphalt pavement surface is less than 3 percent. Structural requirements should then be calculated using the properties of the remaining pavement layers the projected traffic levels (in both directions) and other design perimeters as identified previously in this intersection design guide.

CONCLUSIONS

Even with ever increasing truck traffic and traffic levels, tools now exist to gain top performance from HMA intersections. Well-designed, properly constructed HMA intersections provide an economical, long lasting pavement with minimal disruption. Implementation of an ***intersection strategy*** as outlined in this document will result in a dramatic increase in the performance life of the pavement - reducing life-cycle costs.

CASE STUDIES OF GOOD INTERSECTION DESIGN PRACTICES

Ft. Collins

Several intersections in the City of Ft. Collins have been designed and constructed using the concepts identified in the Guideline. These intersections include Prospect/Lemay, Mulberry/Timberline, Shields/Horsetooth, Drake/Shields, and Shields/Prospect. The first of these was constructed in 1995. Traffic volumes (ADT) range from 42,000 to 55,000 including the heavy truck traffic observed on the Mulberry St. (SH 14) route. These intersections included a 4" mill and fill design as well as others that consisted of full depth rehabilitation. Each intersection is performing well.

The design, construction, and performance of these intersections is a indication of the success agencies can have using the guidelines along with good engineering and construction practices.

View of Shields/Horsetooth Ave. intersection in Ft. Collins using Superpave design as outlined in the Guidelines. This clean, well-designed intersection provides good contrast pavement markings for safe traffic control. The city has used this procedure to obtain excellent performance.

Grand Junction

Successes using good design procedures have been observed on several intersections in Colorado. The design of rehabilitation for intersections at 1st Street and Grand Avenue (I-70 Business Route) in Grand Junction is another example and was used as a reference in the development of the Design Guideline. Rehabilitated in 1997, the intersection carries a large number of heavy trucks and cars. Not only is there a significant amount of stopping and starting but heavy traffic from eastbound I-70 turns at this intersection to go south on US 50.

The intersection was blocked out and constructed at the same time as several other intersections in Grand Junction. A pavement design was developed using a 1/2" nominal mix conforming to Superpave requirements. The mix consists of 30% crushed fines, 5% washed sand, 99% of the course aggregate having two or more crushed faces, and a fine aggregate angularity of 74. The L.A. abrasion of the aggregate yielded 17.2% loss. The asphalt binder used in the mix was a PG 76-28 with an AC content of 5.4% and 3.11% voids (VMA 14.5, FVA 78.5). The repair strategy consisted of a 2" mill and overlay.

Recent performance observations show no signs of cracking from the extreme temperature variations in the Grand Junction area and the high quality mix has withstood the heavy truck turning movements. This intersection provides a good indication of what can be expected when innovative pavement design is matched with Superpave mix design technology for high quality performance aggregates and asphalt binder. It is expected that this intersection will provide quite a few years of maintenance free service.

First and Grand Ave. in Grand Junction. This intersection carries heavy traffic including large trucks from I-70 to US 50. Performance is excellent after six years.

the problem...

With ever increasing congestion at urban intersections; heavy busses and trucks starting and stopping; merchants wanting continuous access to their businesses; and traffic/pedestrian safety concerns; local agencies are challenged to build, rebuild or reconstruct intersections that are cost-effective, long lasting, and with minimal construction impact.

the solution . . . asphalt.

Rocky Mountain News

Monday, March 16, 1998 — DENVER

Drive time gets dicey

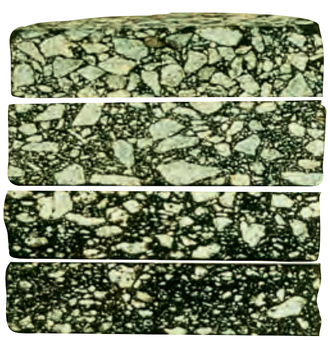
Major downtown construction projects tear up main roads, create traffic snarls. 4A

Lower Cost

With rising prices and intense labor costs for concrete pavement construction, the cost of an asphalt intersection is often half the cost of a concrete intersection, sometimes as low as 30%! Don't forget that more than 90% of the paved road mileage in Colorado is asphalt. The reason is simple – asphalt is less costly to build and maintain than concrete pavement. Asphalt is environmentally acceptable since it is recyclable. It is the life cycle cost solution.

Less Delay

A great advantage of using hot mix asphalt is that it takes significantly less time to construct than concrete. Intersections can be open to traffic within minutes after construction. This results in much less delay and impact on motorists and businesses. In addition, asphalt paving can be completed at night, further lessening the impact of construction on the motoring public and businesses.



New Superpave technology with rut resistant coarse crushed stone. Note stone on stone matrix.

Intermediate mix designs gave marginal results.

outdated mix with high percent of fines and AC tended to rut and shove.

Long Service Life

Through the use of improved materials and mixture designs developed by the Superpave System (see illustration), mixes can now be designed for very high traffic level intersections. These new designs and premium mixes can withstand the loadings and conditions that have resulted in rutting, shoving and cracking in the past.

the solution . . . asphalt.

Colorado Asphalt Pavement Association

Ease of Maintenance

Asphalt street cuts for underground utilities are easier, quicker, and less costly to make – resulting in quicker repairs and less traffic delays than are necessary for concrete intersections. Street cuts often damage electronic traffic detour loops – which are more quickly re-installed in asphalt, lessening traffic flow disruptions.

Safer

Asphalt provides superior driver visibility for pavement markings, especially at night and during wet pavement conditions. This enhances safety for drivers, bicyclists, and pedestrians. White and yellow stripes show up best against smooth black surfaces – helping drivers to be more aware of crosswalks, stop bars, turn lanes, and off-set line stripes at intersections. Also, asphalt provides superior skid resistance without special grooving.

Smoother

There aren't joints, saw cuts, or grooving required in asphalt pavements, so asphalt intersections can be built smoother than concrete and much quieter. Asphalt is a flexible pavement that can be made to easily conform to the grade changes which occur at intersections. Asphalt pavements can be economically maintained to preserve superior ride quality over long periods of time – and smooth roads keep the traveling public happy.

Consider the many advantages of hot mix asphalt.

hot mix asphalt . . .
is the right choice.

Proper design, combined with quality materials and construction workmanship can make hot mix asphalt a long term construction solution for even the most heavily trafficked intersections in Colorado.

Considered with its many benefits – reduced cost, ease of maintenance, reduced delay and construction impact – asphalt pavement is the right choice for Colorado intersections.

HMA

- Costs Less
- Causes Less Delay
- Rides Smoother
- Allows Easy Maintenance
- Safer

To find out more about the advantages of asphalt pavement at intersections or for technical support, call your local CAPA asphalt producer or:

ASPHALT 100% RECYCLABLE

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Centennial, Colorado • (303) 741-6150 • Fax: (303) 741-6146
e-mail – office@co-asphalt.com • www.co-asphalt.com

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