Colorado Asphalt Pavement Association

# Design and Construction of Asphalt Pavement Trails & Paths

4th edition, 2018

# ENJOYING THE COLORADO OUTDOORS

With Colorado's emphasis on health, conservation, the outdoors and the environment, use of trails and paths is a significant part of the Colorado lifestyle. In order to meet public demands for recreational paths and trails, funding continues to increase. Once used by only a few enthusiastic cyclists, paths are now needed for joggers, walkers and recreationalists. Asphalt pavement materials (APM) provides a smooth, flexible, long lasting surface preferred by the outdoor enthusiast for recreational purposes and for use as a means of transportation and links to public transportation centers.

This document is intended to provide guidelines for the proper design and construction of asphalt pavements for trails and paths in Colorado. A cost comparison of asphalt versus concrete is included as well as information on the advantages of using asphalt pavement. The guide concludes with a summary of key factors contributing to quality asphalt pavement paths and trails.

Properly designed asphalt pavements provide user friendly, cost effective, long lasting bike paths and trails which enable the public to use a surface which is smooth, quiet and safe.

**ACKNOWLEDGEMENTS**

*This document is a product of the Colorado Asphalt Pavement Association. The primary author was Mr. Eric West, P.E., WesTest Inc. We appreciate and acknowledge the effort by Mr. West in its development.*

*This document is not intended to replace or supersede any established standard or specification requirement. It is intended to be a resource for the proper design and construction of asphalt trails and paths in Colorado.*

*This is the 4th edition. Previous editions were issued in 1998, 2001 and 2005.*

# OVERVIEW

With Colorado's emphasis on health, conservation, the outdoors and the environment, use of trails and paths is a significant part of the Colorado lifestyle. In order to meet public demands for recreational paths and trails, funding continues to increase by a variety of sources including the Federal Government, the Colorado Lottery the Great Outdoors Colorado (GoCo) Trust Fund. The State Trails Grants are a partnership between Colorado State Parks, Great Outdoors Colorado, the Colorado Off-Highway Recreation Fund, and the Recreation Trails Program.

Funding and use of trails in the state of Colorado has risen dramatically in recent years. Once used by only a few enthusiastic cyclists, paths are now needed for joggers, walkers and recreationalists. Asphalt pavement provides a smooth, flexible, long lasting surface preferred by the outdoor enthusiast for recreational purposes and for use as a means of transportation and links to public transportation centers.

This document is intended to provide guidelines for design and construction of asphalt pavements for trails and paths. A cost comparison of asphalt versus concrete is included as well as information on the advantages of using asphalt pavement. The guide concludes with a summary of key factors contributing to quality asphalt pavement paths and trails.

In order to properly design and construct asphalt pavements, several factors must be considered. Pavements need to be designed to fit the needs of the people. The existing terrain, environment, climate, drainage and, depending on use, pavement loading needs to be addressed in the design phase. These factors, in conjunction with soil characteristics, will affect the design thickness of the pavement as well as the design of the asphalt mixture.

The selection of surface material for trails and paths is primarily based on anticipated type and intensity of trail use. Other considerations of surface material include, terrain, climate, design life, maintenance, cost, and availability. Soft surface materials include earth, grass, bark and wood decking. Hard surface materials include stone, brick, concrete and asphalt. Hard surface materials are preferred for multi-use trails where usage is high.

Each surface material type has advantages and disadvantages. Soft surface materials are low cost but require substantial maintenance and are not suitable for many of the recreational activities today's trails and paths are used for. Hard surface materials, specifically concrete and asphalt, provide years of service with low maintenance.

The designer must consider all the selection variables and stay within budget constraints. It is common for trails projects to be budget constrained. A typical pavement design consists of using full depth asphalt pavement sections or composite sections consisting of asphalt pavement overlying aggregate base course. Most designers have found that asphalt pavement provides better performance because it is flexible and withstands movement associated with frost susceptible soil in mountain climates. If movement does occur, asphalt is easier to repair.

# SELECTING THE PROPER PAVEMENT TYPE

Both the asphalt pavement industry and ready-mix concrete industry are well represented in Colorado. Each product can provide excellent quality for specific applications. There are several factors that should be considered prior to selecting the appropriate pavement type.

## USER PREFERENCE

Asphalt pavement provides a continuous, smooth, joint-free travel lane. This flexible pavement alternative is quieter with improved rideability preferred for cycling and rollerblading. Joggers and walkers also prefer the softer surface asphalt pavement delivers.

## AESTHETICS

Paving techniques allow asphalt pavement to be placed on minor slopes, over undulating topography, and blended into the existing landscape. The free flow lines of asphalt pavement do not detract from the natural environment. In addition, asphalt pavement can be colored to preserve the natural setting. Color may be accomplished using available polymer pigments, or by specifying colored aggregate which will provide a base color more visible through time.

## COST

An analysis of typical construction costs for both pavement types indicates a significant savings can be realized by using asphalt pavement. When properly constructed, using the criteria presented in this guideline and recommendations from your landscape architect or geo-technical engineer, a 20-year design life with periodic maintenance will be realized.

**It is recommended that asphalt pavement thickness be a minimum three inches (3”) for pavements which will be placed on good soil and subjected to minimal vehicle use**. Pavements which will support additional loading and/or be placed on poorer sub-grade will be thicker.

**It is recommended that the minimum thickness of a high-quality aggregate base course be a minimum of six inches (6”) for an asphalt trail.** Thicker base courses should be used for poorer quality sub-grade material.

Outlined below are cost comparisons for asphalt pavement and concrete. Two alternatives are presented and each alternative is presented for metropolitan area construction and remote area construction.

Actual construction costs will vary depending on project specifics, grading requirements, location and local pricing differences, and distance from concrete or asphalt supplier plants.

# PAVEMENT MATERIAL COST COMPARISON

| PAVEMENT THICKNESS | ASPHALT | CONCRETE | ASPHALT SAVINGS |
|---|---|---|---|
| **10’ WIDE PATH – COST PER LINEAL FOOT (Metropolitan Area)** | | | |
| **Minimum**<br>**Concrete = 4”**<br>**Asphalt = 3”** | $9.00<br>to<br>$11.50 | $19.50<br>to<br>$22.00 | **50 %** |
| **Vehicle Use**<br>**Concrete = 6”**<br>**Asphalt = 5”** | $14.50<br>to<br>$17.00 | $23.00<br>to<br>$25.00 | **35 %** |
| **10’ WIDE PATH – COST PER LINEAL FOOT (Remote Area)** | | | |
| **Minimum**<br>**Concrete = 4”**<br>**Asphalt = 3”** | $15.50<br>to<br>$18.00 | $41.00<br>to<br>$46.00 | **60 %** |
| **Vehicle Use**<br>**Concrete = 6”**<br>**Asphalt = 5”** | $34.00<br>to<br>$36.00 | $47.00<br>to<br>$54.00 | **30 %** |

## CONSTRUCTABILITY

Asphalt pavements can be constructed where space is limited, and topography is rugged. In addition to the direct savings outlined above, indirect savings also occur when using asphalt pavement. Construction time is significantly shorter for asphalt pavement. This shorter construction time provides additional savings to the agency by reducing field inspection and management costs. The public also has access to the paths or trails sooner. In some mountain locations, where the construction season is short, this reduced construction time can be a determining factor in the type of pavement selected.

## MAINTENANCE

Asphalt pavement maintenance is kept to a minimum through proper design and construction. A significant advantage over concrete pavement is asphalt’s ability to be repaired quickly and inexpensively. In areas where poor soil conditions exist, concrete slab movement caused by differential settlement can be costly to repair, requiring grinding of edges and/or expensive slab section replacement.

Asphalt pavement repairs can be made quickly and less costly and blended into the existing pavement structure. Many mountain trails are subject to springtime flooding and washout. These sections, when constructed with asphalt pavement, are not nearly as expensive to replace.

# PAVEMENT DESIGN

## PAVEMENT WIDTH

Trail width selection is based on the intended use of the path. Multi-use trails must be wide enough to accommodate fast-moving bicyclists and skaters along with slower moving pedestrians and joggers. Unless rigorous enforcement is anticipated, trails and paths must accommodate two-way traffic**. The minimum recommended width for two-way multi-use paths is ten feet, with twelve feet recommended for heavy use areas.** Sight distance also affects the choice of pavement width for multi-use paths. Adequate pavement width should be provided to allow passing of slower moving users. If possible, trails and paths should be designed with a ten-foot-wide, hard surfaced primary lane for bicyclists and skaters, and a separate five-foot-wide soft surfaced trail for pedestrians and equestrians. In order to design for cost effective construction, the designer needs to consider construction equipment size. Typical paver width is ten feet, with eight feet available in some locations. Design guidelines for path width, sight distance and other safety and user-friendly features are outlined in the *Guide for the Development of Bicycle Facilities,* AASHTO Task Force on Geometric Design (2012). Trail design should also meet the Americans With Disabilities Act, including maximum slope and cross pitch requirements.

## PAVEMENT THICKNESS

The first step in analyzing pavement thickness is determining the loading the pavement will be subjected to. Pavements need to be designed to support wheel loads from vehicles that will have access to them. These may include emergency, patrol, snow removal, maintenance and other motor vehicles.

The next step is to determine the load carrying characteristics of the native soil. A soils investigation should be performed to determine the sub-grade strength, load support capabilities, and ground water conditions. In some areas, the swell potential of the native soils must also be addressed. The soil investigation should be performed with test hole locations at appropriate intervals to account for the varying soil conditions that may be encountered.

Pavement thickness is dependent on the loading that will be applied to the pavement, the asphalt mix design and the ability of the underlying soil to support the loads. Full depth asphalt pavement is the overwhelming choice to distribute loads to the sub-grade. However, depending on the existing soil's ability to support the loads, an aggregate base course and/or geo-textile may be used to improve the stability and/or load carrying capability of the native soil.

The geo-technical engineer performing the soils investigation should recommend design thicknesses for the pavement based on the anticipated loading conditions provided to him by the owner, and the results of strength testing performed on the native soils. As soil conditions vary across the site, recommended design thickness may change. The standards for determining the supporting capabilities of the native soil vary in Colorado. The most common test performed is the R-value, American Association of State Highway and Transportation Officials (AASHTO) designation T-190 and T-99, American Society for Testing and Materials (ASTM) designation D 2844. This test provides a relative soil strength to be applied to nomographs, or design equations, which include environmental and loading criteria for determination of a required structural number for the pavement. The required structural number must be achieved by providing an adequate thickness of pavement. Each pavement layer is assigned a strength coefficient. These strength coefficients are based on the type of material used. A dense graded APM is assigned a strength coefficient of 0.44, based on research done by AASHTO, and the properties of the mix.

In an area with reasonably good soil (R-value > 20), occasional maintenance vehicle use, and good drainage, a required structural number of approximately 1.6 is determined from design nomographs. An example to determine the necessary thickness of APM is as follows; divide the structural number by the strength coefficient of the material, for a typical APM, we will assume a strength coefficient of 0.44. The calculation of 1.6/0.44 provides an example pavement section of 4 inches of APM.

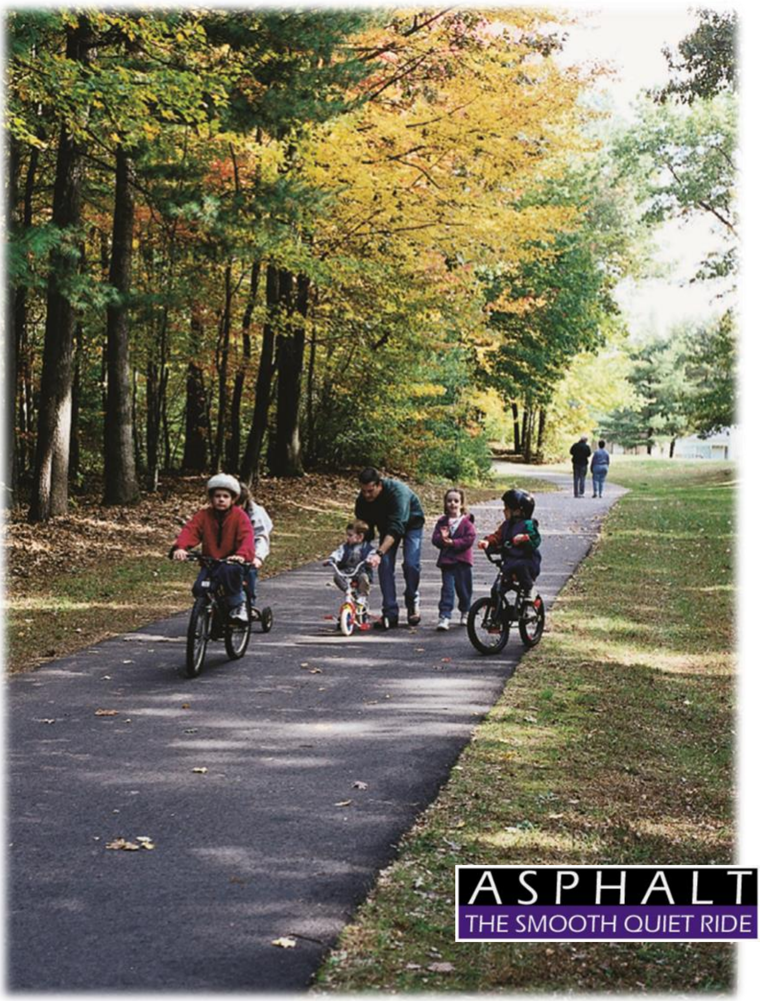
The above is a typical example of the method used by geo-technical engineers to provide recommended pavement sections. It is based on numerous assumptions and should not be used for actual construction. Your geo-technical engineer or landscape architect will provide site-specific information for your project.

In general, it is **recommended a minimum 3" of APM be used for bike paths and trails where loading from vehicles will be negligible**. As soil conditions deteriorate and loading increases, the pavement thickness should be increased.

Composite sections, consisting of asphalt pavement overlying aggregate base course, are common in Colorado. One advantage of a composite section is the ease of grading the base course to the proper level for placement of the asphalt pavement. If base course is used, a CDOT Class 5 or 6 gradation should be specified. Class 5 base course is a minus 1-1/2" aggregate size and Class 6 base course is a minus 3/4" aggregate size. The strength coefficient of base course ranges from 0.12 to 0.14, depending on the R-value of the material. Based on this strength coefficient, three inches of base course are equivalent to the strength of one inch of asphalt pavement. However, when using aggregate base course, it is preferable the asphalt pavement thickness be maintained at three inches and should never be less than two inches.

**It is recommended that the minimum thickness of a high-quality aggregate base course be a minimum of six inches for an asphalt trail.** Thicker base courses should be used for poorer quality sub-grade material.

Development of pavement section recommendations assumes a properly prepared sub-grade. The subgrade should be stripped of vegetation, shaped to grade and compacted at the proper moisture content prior to placement of the pavement structure. In general, compacting the sub-grade to a minimum of ninety-five percent of the maximum density as determined by AASHTO T 99, Standard Proctor, will provide adequate support. The moisture content of the sub-grade should be controlled to within 3% of optimum moisture. A geotechnical engineer or landscape architect should provide guidelines for proper compaction of the existing soil.



# ASPHALT PAVEMENT MIX (APM) DESIGN

Not all APM is the same, and the type of mix used for a state highway is not generally an appropriate mix for a trail or bike path. Specific mixes are designed for specific applications.

The APM specified for your project should provide adequate strength and durability. The overall objective for the design of asphalt paving mixtures is to determine a cost-effective blend of aggregates and asphalt that yields a mix having: sufficient asphalt to provide durability, adequate stability to resist distortion and displacement, sufficient voids to provide for expansion and contraction due to temperature fluctuations, sufficient workability to allow proper field compaction to resist moisture damage and minimize segregation, proper aggregate texture and hardness to provide sufficient skid resistance. Proper portioning of aggregate and asphalt provides a balance among these properties.

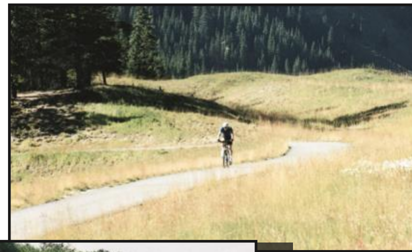
Specifications prepared for trail and bike path APM should be written to address the application the asphalt pavement will be used for. Specifications should be general to allow the use of locally available aggregate, where its quality is adequate for the project. The gradation specification should be consistent with local specifications. **It is recommended that a SX 1/2” nominal maximum size gradation, meeting the following Colorado Department of Transportation (CDOT) criteria, be specified.**

**RECOMMENDED ASPHALT MIXTURE GRADATION SPECIFICATION**

| SIEVE SIZE | GRADING SX MASTER RANGE PERCENT PASSING | PRODUCTION TOLERANCE FROM JOB MIX FORMULA |
|---|---|---|
| 3/4" | 100 | 0 |
| ½" | 90 - 100 | > 90 |
| 3/8" | | +/- 6 |
| # 4 | | +/- 5 |
| # 8 | 28 - 58 | +/- 5 |
| # 16 | | |
| # 30 | | +/- 4 |
| # 50 | | |
| # 100 | | |
| # 200 | 2 - 10 | +/- 2 |

## MAINTENANCE

Trails placed alongside river beds or other poor soil locations are susceptible to differential settling, heaving, and wash out. Asphalt is not nearly as expensive to repair or replace as concrete because grinding and slab replacement costs are avoided. If a proper preventive and corrective maintenance program is established, asphalt maintenance costs can be kept to a minimum, resulting in easier to maintain pavements.



*Near Vail Pass*

*Concrete trail collapsed on Poudre River near Ft. Collins*

## CONSTRUCTABILITY

The time of construction and repair for asphalt pavements is much less that for concrete and asphalt pavements can be constructed with mini mal impact on the existing terrain and environment. This is especially important for those locations where vegetation and tree growth impact during construction is kept to an absolute minimum.

Colorado Asphalt
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Columbine Trail, Arapahoe County

## USER PREFERENCE

Roller-blades, cyclists, and handicap users overwhelmingly prefer the continuous, joint-free travel that asphalt provides. This flexible pavement is softer, more forgiving, quieter, and provides the #1 characteristic that all users are looking for – smoothness.

## AESTHETICS

Asphalt pavement construction techniques allow it to be placed on minor slopes and blended into the existing topography. In addition, many users are preserving the natural setting of trails by customizing their color through the use of polymer pigment or with colored aggregates. This color enhancement allows an asphalt trail to blend in more naturally with its environment.


Summit County Bike Path

Ten Mile Creek Trail (Frisco / Copper Mountain)

## COST

An analysis of typical construction costs for both pavement types indicate a significant initial cost savings can be realized by using asphalt pavement. Also, if properly designed and constructed, the life cycle costs of asphalt pavement trails have been found to be the equivalent to concrete. Asphalt pavement is very often the pavement of choice and recommended by designers for those organizations or agencies with limited budgets.

Aggregate quality should meet the requirements as shown below.

| Aggregate Properties | | |
|---|---|---|
| **Aggregate Test Property** | **Course – Retained on #4** | **Fine – Passing on #4** |
| Fine Aggregate Angularity CP 5113 Method A | | 40% minimum |
| Two Fractured Faces | 60% | - |
| L.A. Abrasion, AASHTO T96 | 40% maximum | - |
| Sand Equivalent, AASHTO T176 | - | 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, course textured, cube shaped particles.

Asphalt pavements for bike paths and trails are not subjected to heavy loading. Many of these paths are also constructed in terrain difficult for large construction equipment to access. Based on these criteria, the APM design should be a mixture with a reasonably high asphalt cement content. This "rich" mix will provide excellent durability and allow for ease of placement and compaction. In addition, high asphalt binder content mixes reduce segregation potential and improve the surface texture of the mix for this type of application.

The asphalt cement content of a mix designed for trail and path construction in Colorado typically ranges from approximately 5.5% to 6.5%. This range is provided for information only and should not be a part of the specifications. The specification for Voids in Mineral Aggregate (VMA), outlined below, ensures a mix with adequate asphalt cement and air voids to provide a durable pavement.

Superpave mix designs are predominantly used in Colorado. There are some locations in the state where the Marshall method is still being used. Outlined below are general design criteria for mixture designs using either of these two methods.

The choice of asphalt cement, or asphalt binder, to be specified will depend on the climactic conditions of the region. **In general, a PG 58-28 is used along the Colorado front-range and at elevations over 7,000 feet. A PG 64-22 is used on the eastern plains.**

Mix designs meeting the above criteria will provide an excellent, long lasting pavement for cyclists, walkers, joggers and rollerbladers. It is important to note that using mix design criteria developed for higher traffic volumes (e.g. major arterials and highways) will not provide a mix with sufficient durability and workability for bike path application. Mix design criteria must be representative of the anticipated loading. A mix developed for highway construction will generally contain less asphalt cement and be more prone to oxidation, raveling and cracking on trails and bike paths. Designs developed for low volume application, as outlined above, will compact easier, remain more flexible and provide excellent service life.

# RECOMMENDED ASPHALT MIX DESIGN CRITERIA

| DESIGN CRITERIA | SUPERPAVE METHOD |
|---|---|
| **COMPACTION** | 50 GYRATIONS |
| **STABILITY** | N/A |
| **FLOW** | N/A |
| **% AIR VOIDS** | 3 -5 |
| **% VOIDS IN MINERAL AGGREGATE** | 15 MIN. FOR ½" NOMINAL 4.0% VOIDS |
| **% VOIDS FILLED** | 70 – 80 |
| **TENSILE STRENGTH RATIO (%)** | 80 MIN. |

*Laboratory compaction effort should be designed to correlate to anticipated traffic loading.*

*Standard mix design practice is to target 3.5 % air voids in the design phase for bike paths and trails. The designer may specify a range of air voids less than 3 % to 5 % (e.g. 2.5 % to 4.5 %) in order to increase the asphalt cement content, improve workability and increase durability for low volume pathways.*

*Asphalt mixes can be customized for the use and application. A trails mix is much different than a highway mix.*

# GENERAL CONSTRUCTION GUIDELINES

Proper construction of asphalt pavement will ensure a project that provides good serviceability throughout its design life. Recommendations provided by the geo-technical engineer should be followed during construction.

The following are several of the key elements to quality construction;

- proper drainage
- proper sub-grade compaction
- adequate pavement thickness
- adequate pavement compaction

## SUBGRADE

Prior to construction, vegetation should be cleared, and stumps and roots removed along the trail for a minimum of five feet outside the edge of the proposed pavement. This will allow construction equipment access and help prevent roots and growth from eventually encroaching on the path. If adequate access width cannot be provided, the contractor will be forced to use less efficient equipment with increased costs to the owner.

Bike paths and trails should be constructed to match the existing topography as closely as possible, however, longitudinal slopes should not exceed five percent and a **cross slope of two percent is desirable to provide adequate drainage away from the pavement surface**. Proper drainage is one of the most important factors affecting pavement performance. Proper drainage entails efficient removal of excess water from the trail. Surface water runoff should be handled using swales, ditches and sheet flow. Catch basins, drain inlets, culverts and underground piping may also be necessary. These structures should be located off the pavement structure.

The asphalt should be placed on compacted sub-grade that extends a minimum of two feet beyond the edge of pavement. The edge of pavement should be feathered with native soil to avoid any sharp drops from the trail edge. The sub-grade should be prepared by removing vegetation, topsoil and unstable soil, shaping to grade, scarifying the surface to a minimum depth of six inches, moisture conditioning and compacting. The sub-grade should be compacted to a minimum of 95% of standard Proctor density, AASHTO T 99, and the moisture should be maintained within 3% of optimum. If aggregate base course is used in the pavement section it should be compacted to a minimum of 95% of modified Proctor density, AASHTO T 180, ASTM D 1557. Depending on the soil conditions, compaction and moisture criteria may vary. Consult your landscape architect or geo-technical engineer for site-specific information. After compaction a soil sterilant and/ or root inhibitor should be applied. Application should be carefully controlled to the pavement area only. Typical shaping, grading and compaction crews consist of a motor grader or blade, landscape tractor with back box for grading, and a rubber tire roller for compaction. Additional compaction equipment and access to water may be required.

Prior to placement of the asphalt pavement it is recommended the **sub-grade be proof rolled to highlight areas of uncompacted or unstable soil**. This may be accomplished using a loaded single axle or tandem dump truck or a loaded rubber tire loader. Soft or unstable areas should be recompacted or removed and replaced with stable soil. It is also important that all utility installations, including sprinkler systems, be complete prior to paving.

## PLACEMENT

Placement of the APM should be accomplished with a self-propelled paver, where possible. Where pavers cannot be used a spreader box, attached to a dump truck may be used. Minimum paver width is generally eight feet. For widths less than eight feet cutoff shoes may be placed in the screed to reduce the width of paving. The screed controls mat thickness and crown. Vibratory screeds are typical and provide a small amount of compaction prior to rolling. In general, **the uncompacted mat should be 1/4 inch per inch thicker than the final desired thickness (example: 3" mat placed at 3 3/4")** to allow for densification during rolling operations.

The APM should be delivered to the paver at a temperature adequate to allow proper compaction. The contractor or the supplier of the asphalt cement should provide recommended compaction temperatures. Compaction temperature varies depending upon the type of asphalt cement used, but generally ranges between 235 degrees Fahrenheit to 280 degrees Fahrenheit. Inclusion of a Workability Mix Additive (WMA) into the APM will allow the contractor to produce and place the mix at even lower temperatures. The contractor's ability to achieve compaction is dependent on the mix temperature, pavement thickness, subgrade temperature, ambient temperature and wind velocity.

## COMPACTION AND JOINT CONSTRUCTION

Compaction should be accomplished immediately after placement by the paver. Steel wheel vibratory rollers are generally used for initial breakdown rolling behind the paver, followed by a steel wheel finish roller. Depending on the compactibility of the mix, a pneumatic tired roller may also be used. Pneumatic tired rollers tend to pick up the fine aggregate from the surface of the pavement. Proper tire temperature or the use of a release agent will minimize this. The contractor should provide rollers adequate to obtain the specified compaction. It is recommended the APM be compacted to between 92% and 96% of the Theoretical Maximum Specific Gravity, AASHTO designation T 209, ASTM designation D 2041.

Joint construction should be carefully done to ensure a uniform mat. Longitudinal joints occur wherever mats are laid side to side. Longitudinal joints should be constructed with a vertical face or a step taper. The step taper should be constructed with a 1.5" vertical face at the surface, tapered at a 3:1 slope from this point to the subgrade. Prior to placing the adjoining mat the joint should be tack-coated. The new lane of asphalt placed against a longitudinal joint should overlap the existing asphalt by approximately 1 inch. A rake is used to gently bump back the asphalt to the joint line. The mix should not be sprayed across the mat with the rake. Compacting longitudinal joints should be accomplished by rolling from the hot side of the asphalt. The steel wheel roller is placed with the majority of the drum on the hot, newly placed asphalt, with approximately six inches of the drum extending over the cold asphalt.

Transverse joints occur at any point the paver ends work and then resumes at a subsequent time. The end of the paving mat should be cut off vertically prior to resuming paving to allow the full lift thickness to be placed against it. This can be accomplished using lumber as a bulkhead, paving over the lumber and leaving a taper that is removed along with the bulkhead prior to resumption of paving. Another method is to form a papered transverse joint. The paver is stopped at the end of production and heavy wrapping paper is placed along the entire face of the vertical edge of the pavement. The paper extends approximately three to four feet onto the subgrade. The paver resumes paving over the paper to form a taper. Prior to resumption of paving, the paper and material on top of the paper is removed forming a vertical edge.

When paving resumes the vertical edge is tack-coated, heated and the paver backed over the existing asphalt with the screed resting on the previously placed mat. The shims should have a height equal to the expected compacted thickness, e.g., 1/4 inch per inch of material. Mix is delivered to the paver and the paver starts forward slowly. Excess mix left by the paver is bumped back to the joint location and/or removed. The joint is then rolled transversely from the cold side beginning with the roller approximately six inches on the newly placed mat and continuing across in six to twelve-inch increments. Timbers should be placed along the outside edges of the mat to support the roller and minimize distortion of the outside edges.

## MAINTENANCE

Properly constructed asphalt pavement using an appropriate mix design requires minimal maintenance. Providing proper drainage is also a key to reducing maintenance costs. Maintenance is generally divided into two categories, preventative maintenance and corrective maintenance. Preventive maintenance is performed on a regularly scheduled basis to improve the life of the pavement and decrease the rate of deterioration. Corrective maintenance is performed to correct a specific pavement failure or distress area.

Normal periodic maintenance, depending on path location, drainage and climate, should include sweeping the trail of debris. A self-propelled side cast broom is excellent for this.

The path or trail should be inspected on an annual basis to determine the overall condition of the drainage, asphalt pavement, signage, pavement markings and vegetation growth.

Drainage areas should be improved or repaired where problems are noted. Vegetation should be removed from the pavement and surrounding areas where it will affect use of the path. Signage should be repaired, replaced or upgraded.

The asphalt pavement should be inspected for cracks, raveling, disintegration, and premature signs of failure. Cracks which are wide enough (generally 1/4 inch to 1/2 inch) should be thoroughly cleaned, dried and filled with a sealant. The best method is to rout the cracks, clean the crack with compressed air, and pour hot crack filling material into the crack. The crack fill should be left 1/4 inch below the surface of the pavement.

Preventive maintenance should include sealing the surface of the asphalt pavement. Surface seals are used to retard oxidation of the asphalt, restore skid resistance, seal small cracks, provide additional moisture protection to the pavement, and retard raveling of aggregate from the surface. Common surface seals include fog seals, rejuvenators, chip seals and slurry seals. The type of seal used will depend on the age and condition of your pavement. In general, a fog seal will improve the moisture resistance of the pavement, reduce future oxidation and fill small cracks. Chip seals and slurry seals will provide the benefits of fog seals and improve the surface texture and skid resistance of the pavement. Caution should be used on the application of chip seals to trails and paths. Chip seals generally consist of an open graded “coarse” surface which may not be desirable to rollerbladers and road cyclists. Coal tar sealants may also produce a very slick and unsuitable surface.

## INSPECTOR’S ROLE

The inspector’s role is a vital one during asphalt pavement construction. It is the inspector’s job to verify that the requirements of the plans and specifications are met in a safe manner. Anomalies from the plans are the rule rather than the exception, and the inspector must be able to exercise judgement and make decisions that ensure the construction of a quality product that will perform as designed.

Prior to beginning construction, the inspector should familiarize themselves with all aspects of the planned construction, the plans and specifications. Preconstruction meetings are critical to the success of a project. A mandatory preconstruction meeting should be held several weeks prior to beginning work to review the plans and specifications, verify the contractor’s schedule, receipt of submittals such as mix designs and product certifications, and discuss the overall construction techniques and equipment planned to be used to accomplish the construction. This is an excellent opportunity for the contractor to ask questions and discuss potential problems he sees and receive feedback from the contracting agency on how potential situations may be handled. The contracting agency, project engineer, construction inspector, contractor, significant subcontractors, and the geotechnical engineer or testing laboratory, including their field representative, should attend the preconstruction meetings. Minutes of the meeting should be distributed to all participants.

The rapport between the inspector and contractor is critical. The inspector’s main concern is quality; the contractor’s main concern is quantity. Reductions in quality should not be allowed in the interests of quantity. The inspector will obtain better results by diplomatically working with the contractor to obtain the highest quality possible.

The inspector should oversee construction and be available to answer questions or know whom to contact to get answers to questions which may arise. The inspector's role is to verify that the plans and specifications are being adhered to and makes the contractor aware of any deficiencies immediately. The inspector must generally obtain approval from the project engineer for any changes to the design. The contractor's responsibility is to determine how to provide construction in accordance with the plans and specifications. The inspector may work with the surveyors, testing laboratory and traffic control, if necessary, to assist in interpreting the plans and specifications. In general, contractors should provide quality control for their workmanship and materials. The contracting agency provides quality assurance to verify the contractor's quality control results.

The inspector, through daily communication with the contractor, should verify that minimum test frequencies are being adhered to, and should obtain copies of the test results in a timely manner. In general, the inspector should verify that the contractor has the proper lines and grades, subgrade compaction, mix temperature of the delivered APM, quantity of material delivered, compaction of the asphalt pavement, thickness, smoothness and proper joint construction. The inspector should also verify that the mix delivered to the project is within the production tolerances of the mix design submitted for the project. As a minimum, the mix design should be field verified prior to or during the first day's production. This verification provides an assurance that the mix can be produced as designed, or allows the contractor the ability to adjust, as necessary. Normal mix production testing should consist of at least one asphalt content test and one gradation test per day.

Proper inspection is vital to ensuring a quality asphalt pavement is constructed. Inspection keys include; adequate sub-grade temperature at time of paving, level sub-grade that has been properly compacted and passed the proof-roll, and the use of the right paving equipment with trained operators to obtain a smooth, properly compacted asphalt pavement. Here is a list of top tips for the inspector.

## INSPECTOR TIPS FOR TRAIL CONSTRUCTION

1. FAMILIARIZE YOURSELF WITH THE PLANS AND SPECIFICATIONS
2. DEVELOP A RAPPORT WITH THE CONTRACTOR
3. SCHEDULE A PRECONSTRUCTION MEETING
4. VERIFY PLANS AND SPECIFICATIONS ARE BEING MET
5. NOTIFY CONTRACTOR OF ANY DEFICIENCIES IMMEDIATELY
6. VERIFY LINES, GRADES AND DRAINAGE ARE CORRECT
7. VERIFY SUBGRADE AND/OR BASE COURSE HAS BEEN TESTED
8. OBSERVE SUBGRADE PROOFROLL
9. VERIFY QUALITY PLACEMENT AND COMPACTION OF ASPHALT PAVEMENT
10. ENSURE A SAFE WORK ENVIRONMENT

## SUMMARY

Problems associated with the performance of asphalt pavement paths and trails include the growth of weeds and emergence of tree roots, subgrade failure, raveling and high maintenance costs. Properly designed and constructed asphalt pavements together with the proper thickness and proper preparation will help ensure a high-quality product.

It is the responsibility of the pathway design team, comprised of the owner, landscape architect, civil engineer, geo-technical engineer and other professionals, along with the contractor, to ensure the benefits of asphalt pavement are realized.

### KEYS TO QUALITY

- Design to meet the needs of the anticipated users.
- Follow guidelines in AASHTO Guide for the Development of Bicycle Facilities, August 1991, for path width, sight distances, clearance, grade, signage, etc.
- Determine pavement loading.
- Determine load carrying characteristics of native soil.
- Design pavement section to meet soil, loading and environmental conditions.
- Provide good drainage.
- Design asphalt mixture to meet loading conditions.
- Properly compact asphalt pavement.
- Plan preventive maintenance.

This guide has been prepared to aid in the proper design and construction of asphalt pavement for paths and trails. Specifying asphalt pavement trails and paths provides the agency and public with numerous benefits.

### BENEFITS OF ASPHALT PAVEMENT

- Cost effective construction providing the consumer with more miles of usable paths.
- A user-friendly surface providing a smooth, quiet, continuous surface with no joints for more enjoyable cycling or rollerblading.
- A flexible surface more forgiving for walkers and joggers.
- An aesthetically pleasing pavement surface which is constructed to blend with existing contours.
- A low maintenance surface providing ease of repair if springtime flooding or soil heaving occurs.
- Reduced construction time allowing more efficient use of personnel and increased trail use by the public.

# Sample Specification for Hot Mix Asphalt Trails and Paths

**Hot Mix Asphalt**

Hot Mix Asphalt shall be an approved design consisting of Aggregate Grading SX as defined in CDOT 703.04 and superpave performance graded binder PG 58-28 conforming to the requirements of CDOT 702.2. Contractor shall submit a proposed job mix gradation which satisfies the Materials requirements of CDOT Section 401. An approved anti-strip agent from the CDOT approved products list may be used in lieu of hydrated lime. An emulsified asphalt tack coat shall be applied between lifts of Hot Mix Asphalt conforming to CDOT 702.03.

The Asphalt Mix Design Criteria shall conform to the following Superpave methodology as follows.

| DESIGN CRITERIA | SUPERPAVE METHOD |
|---|---|
| COMPACTION | 50 DESIGN GYRATIONS |
| STABILITY | N/A |
| FLOW | N/A |
| PERCENT AIR VOIDS | 3 - 5 |
| PERCENT VOIDS IN MINERAL AGGREGATE | 15 MIN. FOR ½" NOMINAL @ 4.0% VOIDS |
| PERCENT VOIDS FILLED | 70-80 |
| TENSILE STRENGTH RATIO, % RETAINED | 80 MIN. |

**Sterilant**

Prior to placement of asphalt, an approved sterilant shall be applied to the compacted aggregate base course layer of the trail cross section.

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