1180. Pavement Design

1180.1. Introduction

Alaska's road transportation system is vital to the state's residents and economy. Pavements must withstand a variety of traffic and environmental conditions and must serve the public in a safe and comfortable manner. In addition, pavements are expected to perform over extended periods of time.

This chapter is an overview of the DOT&PF policy and design philosophy for pavements. Detailed policy and procedures that govern Alaska's flexible pavement design are provided in the *Alaska Flexible Pavement Design* (AKFPD) *Manual* and its companion software.

The *AKFPD Manual* is available online at:

http://www.dot.state.ak.us/stwddes/desmaterials/mat_pvmtmgt/pop_flexpaveman.shtml.

1180.2. Pavement Overview

1180.2.1 Pavement Structure

Pavement structure is a layered system of materials built on top of a prepared subgrade to protect it from excessive deformations due to traffic loads. In general, a pavement structure consists of (top to bottom): wearing course, binder course, base course (stabilized or unstabilized) and subbase or selected material (individually or in combination). The principal function of the layers is to distribute traffic load stresses within the pavement structure, thus protecting the subgrade from excessive deflection. Layer properties (i.e. density, strength, and stiffness) normally decrease from the top to the bottom of the system.

1180.2.2 Highway Pavements

A pavement design analysis is required for all roadway projects requiring pavement construction, reconstruction, or rehabilitation. The regional preconstruction engineer is responsible for the final pavement design.

1180.2.3 Non-Highway Pavements

Pavement designs for non-roadway projects, such as parking areas, paths, and sidewalks, do not require the use of the *AKFPD Manual* procedure if the design equivalent single axel load (ESAL) is below 10,000. If the ESALs are 10,000 or more, then follow Section 2.2.4 of the *AKFPD Manual.* The minimum thickness of all non-highway hot mix asphalt pavements shall be 2 inches.

A Type II or III, Class C hot-mix asphalt may be used for parking areas, paths, and sidewalks with low ESALs. Section 401 of the DOT&PF *Standard Specifications for Highway Construction* (specifications) addresses Class C asphalt pavement.

1180.3. Wearing Course

The wearing course is the top layer of a surfacing system that is in direct contact with traffic loads. The wearing course is designed to:

- Provide resistance to abrasion
- Provide a smooth ride
- Resist plastic deformation
- Resist water permeability
- Resist fatigue
- Resist thermal cracking

Available surfacing types are listed in section 7.3 of the *AKFPD Manual.* Following are descriptions of some of the more common types of surfacing DOT&PF uses.

1180.3.1 Hot Mix Asphalt (HMA)

Hot Mix Asphalt (HMA, or asphalt concrete pavement) is the predominant type of wearing course used on DOT&PF roadways. A pavement that receives such a surfacing is called a flexible pavement. HMA is appropriate for highway pavements, parking lots, pathways, and sidewalks.

HMA pavement structures are designed in accordance with the policies and design procedures in the *AKFPD Manual.* Use a minimum thickness of 2 inches for new and overlay HMA layers. The specifications cover HMA in Section 401.

1180.3.2 Asphalt Surface Treatment (AST)

An AST is an asphalt/aggregate application to a road surface. Usually less than 1 inch thick, asphalt surface treatments do not increase the load bearing capacity of pavement structures. They provide friction and decrease dust generation. ASTs are appropriate when unstable embankments are present and/or for low-traffic roadways.

ASTs may be used if any of the following conditions are met (refer to Section 2.1 of the *AKFPD Manual*):

- The AADT is less than 1,000
- Life-cycle cost analysis supports their use
- Unstable foundations underlie more than 60 percent of the project
- The regional preconstruction engineer has approved them

Design ASTs using the *Asphalt Surface Treatment Guide*, which is available online at:

http://www.dot.state.ak.us/stwddes/research/assets/pdf/fhwa_ak_rd_01_03.pdf

Section 405 of the specifications covers ASTs.

1180.3.3 Portland Cement Concrete (PCC)

PCC is rarely used in Alaska pavements. High cost and damage due to foundation settlement preclude its use in roadways.

If a PCC pavement is used, consult the 1993 *AASHTO Guide for Design of Pavement Structures*. Consult the regional materials engineer for special provisions, specific concrete mix designs, and subgrade requirements.

1180.3.4 Gravel Surfacing

See Section 1180.7 for guidance on gravel surfacing.

1180.4. Binder Course

The binder course is the bottom layer of pavement below the wearing course. The binder course supports the wearing course. A binder course has all the properties of a wearing course except that resistance to abrasion is not essential. The minimum thickness of a binder course is 3 inches when placed on top of a non-stabilized base and 2 inches when placed on top of a stabilized base.

The wearing course and binder course may be composed of the same material when advantageous; however, the binder course often has a different asphalt content and gradation or hardness of aggregate. A binder course is not necessarily required in a specific pavement design.

1180.4.1 Hot Mixed Asphalt (HMA)

Binder courses are usually HMAs, but in the case of overlays, the original wearing course layer becomes a binder course layer when topped with a new HMA layer.

The specifications cover HMA materials in Section 401.

1180.4.2 Recycled Asphalt Pavement

Recycled asphalt pavement is the process of recycling old asphalt into new pavement by in-place cold mixing process or hot mixing at a plant. To be considered adequate as a binder course, a recycled asphalt pavement must have a resilient modulus greater than 300 ksi.

Consult the regional materials engineer for recycled asphalt pavement special provisions.

1180.5. Base Course

The base course is the layer of material placed on top of the subbase or subgrade that supports the wearing and binder courses. A base course can be stabilized or non-stabilized.

Use of a bound stabilized base is required on all roadway construction, reconstruction, and rehabilitation projects except for:

1. Projects designed under the *Gravel to Pavement* program
2. Projects exempted in writing by the regional preconstruction engineer. Rationale for an exemption may include:
   - Projects with a low AADT
   - Areas underlain by unstable foundations, such as ice-rich permafrost, where settlement results in frequent maintenance
   - Projects for which a stabilized base will not provide a cost-effective improvement in the pavement performance, reduced maintenance, or reduced future rehabilitation costs through a comprehensive life-cycle cost analysis. The

period of the life-cycle cost analysis shall be 30 years.

- Roads designed on behalf of agencies other than DOT&PF

1180.5.1 Stabilized Bases

Stabilized bases are normally defined as standard base course materials containing one or more of the following binder additives:

- Asphalt emulsion
- Asphalt cement
- Foamed asphalt cement
- Lime
- Portland cement
- Reclaimed asphalt pavement (RAP)

Stabilized bases are used to improve long-term pavement performance, reduce maintenance costs, and reduce future rehabilitation costs. While a stabilized base has no minimum amount of required binder additive, it must achieve a resilient modulus of at least 80 ksi.

The minimum thickness of a stabilized base is 3 inches. In developing flexible pavement designs using stabilized bases, refer to general policies GP5, 6, and 7 in Section 2.1 of the *AKFPD Manual*. In addition, use the following:

1. *Alaska Soil Stabilization Guide* (Report No. FHWA-AK-RD-01-6B)
2. The mechanistic design method used in the AKFPD computer program
3. The definition of stabilized layers as found in Section 7.4.1 of the *AKFPD Manual*

The *Alaska Soil Stabilization Guide* is online at:

http://www.dot.state.ak.us/stwddes/research/assets/pdf/fhwa_ak_rd_01_06b.pdf

The resilient modulus, M_R, of the stabilized base is determined from experience, back calculation, or testing and is a necessary input variable to run the AKFPD analysis program.

Following are stabilized bases used relatively frequently in Alaska:

Asphalt Treated Base (ATB)

Asphalt treated base (ATB) is a stabilized base course constructed using a minimum of 4 percent asphalt cement binder. ATB's primary use is as a binder course in the Alaska Renewable Pavement (ARP) layering system. Refer to sections 7.4.2 and 7.4.3 of the *AKFPD Manual* for a detailed discussion of ATBs and the ARP. To be used as a binder course in the AKFPD method, an ATB must have a resilient modulus greater than 300 ksi.

There is some functional overlap with HMAs, but ATBs have different asphalt oil content, can use softer aggregate, and are less restrictive on aggregate gradation and in placing and leveling requirements. Therefore, they are more economical than HMAs.

Asphalt treated base course is addressed in section 306 of the specifications.

Emulsified Asphalt Treated Base (EATB)

Emulsified asphalt treated base course (EATB) is addressed in section 307 of the specifications.

When used with emulsified asphalt, crushed asphalt base course is also considered a stabilized base. Crushed asphalt base course is covered in Section 308 of the specifications.

Reclaimed Asphalt Pavement (RAP)

Reclaimed asphalt pavement (RAP) that contains greater than 50 percent asphalt concrete pavement or greater than 3 percent residual asphalt content is considered a stabilized base.

1180.5.2 Non-Stabilized Bases

Non-stabilized bases comprise materials that do not have any binder additive. Crushed aggregate is the most common type of base course. Non-stabilized base course layers shall be a minimum of 4 inches thick.

Aggregate base course is covered in Section 301 of the specifications. Reclaimed asphalt pavement (RAP) may be used as base course, or blended with aggregate base course, when produced in accordance with section 308 of the specifications.

1180.6. Subbase/Select Material/Borrow

The lower pavement structure typically includes subbase or selected material, individually or in combination. Where existing natural material is of adequate quality, it may serve as the lower portion of the pavement structure.

Section 304 of the specifications covers subbase.

1180.7. Gravel Roads

1180.7.1 General

Alaska has several existing major gravel roads and gravel surfacing is appropriate for some new, very low-volume roads in rural areas, where dust is not an environmental issue. This section has therefore been included in this "pavement design" section of the *Preconstruction Manual.*

Maintenance cost of gravel roads is considerably higher than that for HMA, AST, or PCC surfaced roads and is an important consideration when performing cost-effective or life-cycle cost analysis.

1180.7.2 Gravel Surface Structure

New Gravel Roads

The following references provide guidance that will assist in design of gravel roads:

- *AKFPD Manual*
- AASHTO *Guidelines for Design of Very Low-Volume Local Roads*
- AASHTO *Design of Pavement Structures-Part II* (Chapter 4 Low-Volume Road Pavement Design)
- Asphalt Institute *MS-1 Thickness Design Asphalt Pavements for Highways and Streets*.

When future paving of a gravel road is planned, evaluate the pavement structure in accordance with the design guidance appropriate to the anticipated future pavement type (i.e. *AKFPD Manual* for HAP).

Consult the regional materials engineer for more specific gravel roadway design guidance. Aggregate surface courses are addressed in section 301 of the specifications.

Consult the regional Maintenance and Operations (M&O) Section to determine if adequate personnel and equipment will be available to maintain the roadway prior to selecting gravel as surfacing.

Existing Gravel Roads

The roadway surfacing design process for existing gravel roads is as follows:

1. Evaluate the existing gravel road for previous performance and drainage system adequacy. M&O should participate.
2. Determine the adequacy of the embankment strength. Consider in the determination that the existing roadway structure will or will not support a base and surface course the recommendations from Materials, and Maintenance and Operations. Supplement as needed by structural support readings (i.e. Falling Weight Deflectometer, California Bearing Ratio, Dynamic Cone Penetrometer) or fines content.

If the embankment has adequate strength, provide sufficient aggregate surface course to shape cross slope and superelevation as a minimum. Aggregate surface course is addressed in section 301 of the specifications.

If the embankment does not have adequate strength, follow the guidance provided in the "New Gravel Roads" portion of this subsection.

1180.8. Glossary

The following is a brief glossary. A comprehensive glossary of asphalt design and construction terminology is found in the *AKFPD Manual.*

AADT: Average Annual Daily Traffic. AADT is a measure of traffic volume.

Asphalt Concrete: Also referred to as asphalt concrete pavement (ACP), hot mix asphalt (HMA), flexible pavement, and hot bituminous pavement. It is the material most commonly used for surfacing roadways and airports in Alaska that are subject to high traffic. ACP is a high-quality, controlled, hot mixture of asphalt cement and graded aggregate, thoroughly compacted into a uniform dense mass.

Emulsified Asphalt: A combination of ground asphalt, emulsifying agents, and water. It cures by "breaking," which is water removal by evaporation or steaming off. Asphalt emulsions fall into three categories: anionic, cationic, and nonionic. The first two types are ordinarily used in roadway construction and maintenance. The anionic (electronegatively charged) and cationic (electropositively charged) classes refer to the electrical charges surrounding the asphalt particles. With nonionic emulsions, the asphalt particles are neutral. Cationic emulsions are used with aggregates that are negatively charged. Anionic emulsions are used with positively charged aggregates. Opposite charges attract. The relative setting time of either slow setting (SS), medium setting (MS), or rapid setting (RS) emulsions further categorizes emulsified asphalts.

Emulsified Asphalt Treated Base (EATB): A product of mixing base course material with emulsified asphalt and sometimes a few percent Portland cement. It can be mixed on grade by heavy equipment or by specially made traveling plants. It can also be produced in a central mixing plant. Emulsified asphalt treated bases bind up P_{200} in base course material and reduce frost heave and high moisture content. They also can create an effective structural support layer so that the otherwise required thickness of pavement or subbase can be reduced.

ESAL: An acronym for Equivalent Single Axle Load. An ESAL is the vertical load of a standard 18,000-pound, dual-tire, single-axle truck. The effect of pavement performance of any combination of axle loads is equated to the number of ESALs.

Mix Design: The project-specific combination of materials to be used in construction of a given pavement.

Resilient Modulus (M_R): An elastic property of pavements and stabilized bases. The resilient modulus is defined as the ratio of repeated axial stress over the recoverable elastic strain.

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