Chapter 1 Asphalt Paving

Common Defect Allegations

- *Movement of the subgrade is the major cause of asphalt pavement failure. Water is the major cause of subgrade movement, beyond poor compaction. The cross slope should be such that there is no water ponding on the surface. Water should be directed away from buildings and paved surfaces.*
- *Ordinarily, defect claims on asphalt include cracking, settling, and alligatoring. Sometimes problems are caused by improper installation, but usually they result from lack of maintenance, or the system has simply run the length of its normal useful life. The insurance industry assigns the normal useful life of various products to establish depreciation schedules. The recognized industry normal useful life of asphalt paving is 10 years. Therefore, asphalt paving that shows deterioration at 9 years and 10 months, for example, is quite ordinary, and not a compensable claim. Traditional maintenance requires that the surface be recoated regularly with a slurry seal or fresh oil and sand to reduce the evaporation of resins from the integral adhesives within the product.*

Introduction

Often there is no written residential standard that clarifies trade custom or defines deficiencies commonly found in defect claims. In the case of asphalt paving on private land (driveways rather than street paving), building codes typically do not address installation. There are, however, some industry standards that are helpful.

This chapter presents these industry standards, in addition to the editors' comments on good practice, which are based on experience in residential asphalt construction and light commercial paving.

The following checklist may be helpful as you review the site in preparation for starting an asphalt paving project.

- ☐ Site cleaning _____
- ☐ Soil type _____
- ☐ Subgrade moisture conditioning _____
- ☐ Subgrade compaction _____
- ☐ Drainage _____
- ☐ Vehicle weight _____
- ☐ Asphalt mix design _____
- ☐ Weather extremes _____
- ☐ Local code _____
- ☐ Local custom _____
- ☐ Edgings _____
- ☐ Special considerations _____

The following resources may be useful for locating additional information on asphalt paving.

Asphalt Paving Alliance (APA)
877-APA-0077
www.asphaltalliance.org

Asphalt Recycling and Reclaiming Association (ARRA)
410-267-0023
www.arra.org

International Society for Asphalt Pavements (ISAP)
651-293-9188
www.asphalt.org

National Center for Asphalt Technology (NCAT)
334-844-6228
www.eng.auburn.edu/center/ncat

National Asphalt Pavement Association (NAPA)
888-468-6499
www.hotmix.org

The Association of Asphalt Paving Technologists (AAPT)
651-293-9188
www.asphalttechnology.org

The Asphalt Handbook
Asphalt Institute
859-288-4960
www.asphaltinstitute.org

The Asphalt Institute produces educational materials to help ensure the proper use of asphalt. The organization offers several publications, including "Model Specifications for Small Paving Jobs" (CL-2).

See Chapter 2 for information on concrete slabs, finishes, and paving, including tolerances, defects, and deterioration.

Ed. Note: Comments and recommendations within this chapter are not intended as a definitive resource for construction activities. For building projects, contractors must rely on the project documents and any applicable code requirements pertaining to their own particular locations.

Green, or Sustainable, Paving Options

Consider permeable (porous) paving materials to reduce runoff where appropriate. Most types of permeable asphalt and concrete are not suitable for heavy traffic areas, where impervious asphalt and concrete paving are the best choices. Permeable paving can be used for parking areas, walkways, lightly used driveways, utility access roads, fire lanes, and highway shoulders. In addition to absorbing runoff, permeable paving helps reduce the "heat island" effect.

Permeable paving materials include gravel or reinforced grass paving for low-traffic areas, block, natural or concrete simulated stone, brick, permeable asphalt or concrete (that do not contain fine aggregate), and structural grid systems. These materials not only prevent runoff onto adjoining property and into storm drains, but can reduce the need to construct water detention and collection areas.

It's important that the property owner be informed of the need for regular surface cleaning of permeable paving to prevent pores from becoming clogged.

Recycled asphalt is another green paving option.

Subgrade Preparation

Comments

While there are no recognized national standards for residential driveway subgrade preparation, the following guidelines are recommended good practice.

Frequently, private asphalt driveways are placed on native soil. Consideration must be made as to soil type. Among the least desirable soil types is expansive clay, and preferable types include crushed stone. When expansive clay is encountered, an aggregate base material might be used to separate the subgrade and the asphalt.

Asphalt pavement is considered flexible. However, it will fail with subgrade movement. In simple terms, the best base is a granular material that will allow water to perk away from the asphalt without expanding or contracting. Design criteria should allow for a slope to divert water away from buildings and paved surfaces without ponding, usually requiring a horizontal surface slope of 1/4" per foot or more.

Subgrade compaction helps support and strengthen the pavement. The thinner pavements commonly used on private driveways require that the subgrade be compact. While compaction and moisture testing is optimal, it is not usually performed on private driveways. Often, project specifications require that weed killer be applied on the subgrade prior to installing the base course.

One cause of bumps and dips in the pavement is lack of smoothness in the subgrade. The grade should be shaped to drain, and should be as smooth as the asphalt pavement that will be placed on it.

In colder climates, water can freeze under the asphalt and expand, causing heaving and cracking. Occasionally, wood 2x edge forms are used at the pavement edges to achieve proper thickness and maintain specified grade. The edge forms should have full bearing on the grade to prevent the roller from driving them down and changing planned grade.

Layers

Industry Standards

Means Graphic Construction Standards

(RSMeans)

Asphalt pavements transfer and distribute traffic loads to the subgrade. For commercial applications, the pavement is typically made up of two layers of material, the wearing course and the base course. The wearing course consists of two layers: the thin surface course and the thicker binder course that bonds the surface course to the heavy base layer underneath.

The base consists of one layer that varies in thickness, type of material, and design, according to the bearing value of the subgrade material. If the subgrade material has a low-bearing value, either the thickness or the flexural strength of the base must be increased to spread the load over a larger area. For residential driveways, typically only an asphalt wearing course, or asphalt with crushed stone base course, would be used.

Increasing the flexural strength of the base course can be accomplished by mixing asphalt with the base material. The addition of the asphalt doubles the load-distributing ability of a conventional granular base. For unstable soils, a layer of geotextile stabilization fabric can be added between the base and the subgrade. This fabric not only adds tensile strength to the base, it also prevents the subgrade material from pumping up and contaminating the base when the different layers are being installed. This method is sometimes used for light commercial projects. For commercial applications, granular base courses usually range from 6" to 18" in thickness. An alternate method is to install polypropylene stablilation fabric, which prevents water from infiltrating into the base course and causing freeze/thaw heaving in colder climates.

Asphalt Pavement for Commercial Applications

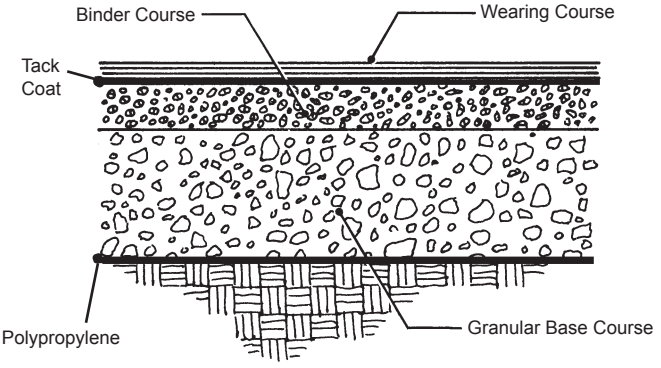


Figure 1.1 RSMeans, *Means Graphic Construction Standards*

Asphalt Placement

Comments

There are no recognized national standards for asphalt placement. However, the following guidelines are recommended good practice.

Do not begin placing asphalt when the atmospheric temperature is below 40°F, and never place asphalt on frozen ground. Asphalt for paving is a mixture of various aggregate sizes and asphalt oil. This mixture is heated and hauled to the job site in open dump trucks.

The mix for private driveways and parking lots is usually finer (no coarse aggregates) than for streets. This makes the surface smoother, with a finer texture. Ideally, you should know what temperature the asphalt should be when it arrives at the site. This information can be obtained from the plant. It is best to check the load in the truck with a thermometer. Experience has shown that an excessive amount of blue smoke will rise from a too-hot mix. If the mix is too cold, it will appear too stiff, and the large aggregate will not be fully coated with asphalt. If the mix levels off in the truck, the contractor has a good indication that there is too much asphalt in the mix. Asphalt is stiff enough when it remains in a pile or heaped in the truck. When there is too little asphalt oil, the mixture will have a brownish color and appear dull. Watch for nonuniform mixture.

Prior to placing the asphalt, all concrete and asphalt edges should be coated with tack coat (emulsified asphalt diluted with water). The tack coat allows the pavement to bond with other materials, helping to seal out water.

Sometimes, residential driveways are too confined and too small to permit the use of a mechanical spreading machine. When this situation occurs, the asphalt mix is dumped on the grade in piles. The piles should be spotted, so workers who are spreading the mix by hand do not walk on the material. If they should step on it, the footprints should be raked out to the full depth of the course. The hand placing should not include casting or throwing the material. An asphalt or lute rake should be used to spread material placed in piles by shovels.

The mixture should be placed to the depth of the final thickness—plus ¼" per 1" of depth—to allow for compaction.

Use a ride-on smooth wheel roller for compaction. Small, inaccessible areas can be compacted by a smooth plate vibrating compactor. Initial rolling should occur as soon as possible. This first roller pass will provide the greatest compaction on the pavement. The drive wheel of the roller should always be forward in the direction of the paving. On very steep grades, this position may have to be reversed. Work from low side to high side for the initial and second passes. Finish rolling (to achieve a smooth surface) should occur when the mix is hot but can barely be touched with the hand.

It is a common practice to use diesel oil to coat lute rakes, shovels, and compactors to keep them clean. This should be minimized as much as possible, because the distillate will damage the asphalt. Heating the shovels and lutes will work well to keep them clean.

If you should run short of paving mix and only need a small quantity to complete a job, you still have to order a ton of mix to keep it warm in transit. Long distances from the plant will require a larger quantity to keep warm. The plant dispatcher should be able to provide guidance on these issues.

Design

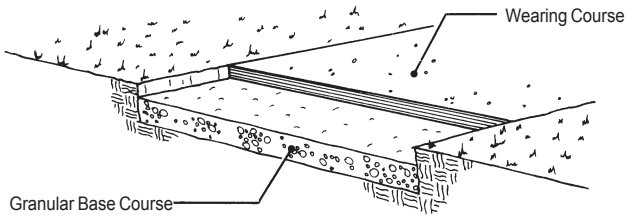
Industry Standards

Means Graphic Construction Standards

(RSMeans)

The thicknesses of the courses within the pavement vary with each layer, according to the intended use of the pavement and, as noted earlier for the base course, the bearing value of the subgrade. For example, pavement may contain a 1" surface course, a 2"–3" binder course, and a 5" or more base course. Standard commercial parking lot pavement may consist of 2½" of wearing surface and 8" of granular base, while a residential driveway may consist of two 2½"–3" wearing course with no binder course.

Bituminous Sidewalk or Driveway



RSMeans, *Means Graphic Construction Standards*

Figure 1.2

Recommendations

National Asphalt Pavement Association (NAPA)

(www.hotmix.org)

Hot mix asphalt is a mixture of aggregate and liquid asphalt cement, combined at a hot mix plant. The advantages of hot mix asphalt include:

- Availability for use immediately after being placed and rolled, with no curing time
- Durability
- Ease of maintenance
- Conformance to varying terrain
- Flexibility (resistance to damage from freeze–thaw)

Asphalt can be mixed in different formulas for different textures and purposes, such as a driveway that also functions as a play area or basketball court.

Full-depth hot mix driveways (constructed of hot mix from the subgrade up, as compared to a stone base with an asphalt layer on top) are more resistant to freeze–thaw and drainage problems, since they provide greater uniform pavement strength and keep water out of the driveway base.

Correct drainage must be figured before installing a new driveway and any low or soft spots corrected. A soil sterilizer should be applied to prevent grass or weeds from germinating and growing up through the pavement at a later date.

When overlaying an existing asphalt driveway with a new one, it is important to first patch and correctly compact all holes and trouble spots. If the driveway has a gate, the gate may need to be rehung to adjust for the increased thickness. If there are surface boxes (for example, water valves) or drainage gratings in the driveway, they may need to be releveled. These items may or may not be covered by the asphalt contractor.

Facilities Operations & Engineering Reference

(RSMeans)

The major issues in pavement design are drainage and the size and amount of traffic that will be operating on the asphalt surface. If it is a parking lot with no anticipated traffic heavier than passenger vehicles, a basic design with 6" of base and 3"–4" of asphalt will be sufficient. If heavy trucks will be operating on the pavement, then a base up to 12", with 6" of asphalt, may be needed. For loading docks, a concrete apron may be appropriate where the trailers will be parked. If a truck is parked for a considerable amount of time, it can depress the pavement underneath. The pavement surface must be strong enough to withstand distortion, resist wear from traffic, and provide both a smooth ride and skid-resistance. The pavement must also be well bonded to the course below.

A well-designed pavement should be free of water after a rain shower. The site should drain out and away from the pavement. Large paved areas should have an elevation plan showing the proposed grades on a grid. The base and sub-base of the pavement system are important to its structural effectiveness. These two elements, with the asphalt surface above, distribute traffic wheel loads and must offer internal strength properties. Full depth asphalt pavements have both tensile and compressive strength to resist internal stresses. Asphalt bases spread the wheel load over broader areas than untreated granular bases. Consequently, full depth asphalt pavements require less total pavement structure in terms of thickness.

Placement Considerations

Facilities Operations & Engineering Reference

(RSMeans)

Contract documents should specify the aggregate mixture, gradation, quality, grade of the asphalt, and the heat ranges at which the aggregate is to be mixed and placed. An engineer designs the project and prepares the plans and specifications, then works with the contractors who will supervise the construction. The engineer inspects the work. The engineer and his or her inspector should discuss the operation before starting the work with the contractor's superintendents and foremen, and should plan the operation together. The *Asphalt Handbook* (published by the Asphalt Institute) recommends discussing these important details:

1. Continuity and sequence of operations
2. Number of pavers needed for the project
3. Number and types of rollers needed
4. Number of trucks required
5. Chain of command for giving and receiving instructions
6. Reasons for possible rejection of the mix
7. Weather and temperature requirements
8. Traffic control

Asphalt concrete is usually placed on a base course. The base course should be well-graded material that is compacted to at least 98% optimum moisture (based on a modified Proctor test). The base course soils are classified in general terms by the predominate particle

size or grading of particle sizes. These are usually gravel, course sand, medium sand, fine sand, silt, clay, and colloids. Well-graded soils contain a mixture of particle sizes and are generally free from organic matter.

The base course should be checked for thickness, elevation, and proper grading, and should be free of loose materials. Prior to placing the asphaltic concrete and before the binder course is installed, a tack coat of asphalt may be sprayed on. The binder course is placed first and contains larger stone sizes and sometimes stone chips. The wearing course, or top course, is made with coarse and fine sand. In cases such as the patching of a driveway or other use of only a small portion of paving material, only the wearing course is put down to save time. Asphaltic concrete is usually placed with a paving machine. Again, it is recommended that tack course be applied between existing or new pavement layers for good binding. The top course is usually hand-raked on the edges.

Truckloads of material should be inspected as they arrive, and the mix temperature checked on a regular basis. The paving inspector may reject loads that do not meet tolerance criteria. The paving crew must stay in close touch with the asphalt plant to communicate any changes needed in the mixture for subsequent truckloads. Records should be kept of loads placed, as well as any that are rejected.

The temperature of the mix is crucial. If too low, it will not compact properly. Too high and the curb may slough off. Temperatures generally range from 120–140 degrees Celsius (250–285 degrees Fahrenheit).

Compaction is accomplished with rolling equipment, as soon as possible after the hot asphalt mix has been spread. Rolling is usually done in three passes: first, the breakdown to compact the material; second, the intermediate rolling to create further density and seal the surface; and lastly, finish rolling to remove roller marks from previous passes.

Once rolling is complete, the surface should be checked to ensure there are no defects. Those that can be corrected by additional rolling should be addressed by placing fresh, hot asphalt and compacting it before the surrounding area cools (below 85 degrees). Tolerances for smoothness must be ensured. Most specifications provide for a transverse variation no greater than 6mm in 3m, or ¼" in 10'. Variations from the tolerance levels in any layer should be corrected before placing the next layer.

Sampling & Testing

Facilities Operations & Engineering Reference
(RSMeans)

First the subgrade is tested for compaction. This can be done with a modified Proctor test or a nuclear density test. The modified Proctor test involves taking an in-place sample of the subgrade, then utilizing a lab test to determine the moisture content of the soil at which maximum compaction can be obtained. Nuclear density tests have become more common now because results can be obtained instantly and they are nondestructive. Sampling allows the contractor to correct any areas that are not adequately compacted.

Testing asphaltic concrete generally involves temperature monitoring during the installation and sampling of the material in place. Sampling can be done by core-drilling a sample and having a lab test it. Nuclear density testing can also be performed on in-place asphalt. The average of the densities from the samples obtained must meet targets based on percentages set by the lab, by maximum possible (theoretical) density, and by control strip density.

Resurfacing Existing Roadways

Facilities Operations & Engineering Reference
(RSMeans)

The surface of an existing road should be examined before beginning any resurfacing work. Scarifying, recompacting, or repair of the old surface may be necessary before placing new material. If there are any soft spots or irregularities, these should be addressed. It may be necessary to patch or remove excess asphalt. Application of tack coat before any new asphalt layers are placed is highly recommended. Adequate time must be allowed for consolidation of patches before performing final surface preparations. Correction of drainage problems is extremely important.

These kinds of repairs often fall into the category of maintenance. In some cases, maintenance repairs may be addressed as temporary measures. Asphalt concrete and other types of hot mixes offer a more durable and lasting solution, and should be used when practical. Alternatives, including cold-plant and road mix materials that contain medium curing or emulsified asphalt, can be used right away or stored for a short time. Materials with slow-curing asphalt or a solvent emulsion can be stored for a longer time for patching. Patching should be done before cracks lead to larger problem areas by allowing water to enter the subgrade.

Full-Depth Asphalt Pavements for Private Driveways

Industry Standards

Asphalt Institute (AI)

(www.asphaltinstitute.org)

Drainage

Good drainage is important for pavement durability. It is desirable to blend the surface of the pavement to the contour of the existing ground so that the surface water runs over it or away from it in its natural course. In flat areas, the driveway should be sloped or crowned not less that ¼ in./ft. (2 cm/m) so all surface water will drain off. Roof drainage from downspouts should, if feasible, be piped well away from the edge of the driveway. In some cases, pipe cross drains may be needed to take the water under the driveway. Water should not be allowed to stand at the edges.

Generally, an underdrain system is not required when the pavement is constructed by the full-depth asphalt method, even over poor soil or in certain other undesirable drainage conditions. However, an underdrain system may be required if the driveway pavement is constructed using an untreated gravel or crushed rock base.

Pavement Width

Primary consideration should be given to building a driveway of proper width. It should be no less than 8 ft (2.4 m), but 10 ft (3 m) is a more practical minimum width. If the driveway will be used for both pedestrians and automobiles a 12 ft (3.7 m) width should be considered.

It usually is desirable to preserve aesthetic objects such as trees and rocks. Also, to avoid unsightly cuts in hilly areas, driveways should conform to the terrain. Therefore, where the property will accommodate it, a curving driveway will be more attractive. A curved driveway needs to be wider in sharp curves.

Pavement Thickness

Full-depth asphalt pavements for residential driveways should have a minimum of 4 in. (10 cm) compacted thickness on a properly prepared subgrade (see Subgrade Preparation, below). This minimum is sufficient for many years of service (automobiles and an occasional truck) if the driveway is properly constructed. However, if there is concern about foundation conditions, such as soft subgrade or an exceptional number of heavy vehicles using the pavement, it may be desirable to increase the thickness to 5 in. (13 cm), or under extreme conditions, 6 in. (15 cm).

Ed. Note: The Asphalt Institute offers further information on thickness design in two reports, "Full-Depth Asphalt Pavements for Parking Lots" and "Service Stations and Driveways."

Subgrade Preparation

Before construction begins, buried utility lines in the vicinity of the driveway should be located. If they are likely to be damaged during construction, they should be relocated or protected. The subgrade soil must serve as a working platform to support construction equipment, and it also must serve as the foundation for the pavement structure. Because it must be capable of carrying the loads transmitted to it from the pavement structure, it is most important that the subgrade be properly graded and adequately compacted.

After grading and compacting with a roller, the subgrade should be tested to determine if it will support the construction equipment. This is done by driving a heavily loaded truck over it and noting the deflections. If part of the subgrade shows pronounced deflection, this indicates that the soil has not been sufficiently rolled or that the soil-moisture content of the subgrade is too high. If additional rolling fails to correct the unstable condition, the soft areas should be removed and replaced with 2 or 3 in. (5–8 cm) of hot-mix asphalt. In some cases of extremely poor subgrade, it may be necessary to remove the upper portion of the subgrade and replace it with better material.

Where it is possible that weeds may grow in the subgrade soil, the subgrade should be treated with a non-toxic commercial sterilant prior to paving.

Composition of Paving Mixture

It is recommended that the asphalt paving mixture to be used be of a type locally and readily available. Typically this would be a state highway department mix used for residential streets. Because they are used extensively, these mixes are usually the least expensive. If such locally specified mixes are not available, it is advisable to use the American Society for Testing and Materials Standard Specification D351 5, "Hot-Mixed, Hot-Laid Asphalt Paving Mixtures." Mix Designations and Nominal Maximum Size of Aggregate, ½ in. (12.5 mm) or ⅜ in. (9.5 mm) are recommended.

Spreading the Mixture

The thick lift technique (placing in lifts of 4 or more in. [10 or more cm]) is in most instances satisfactory. However, if subgrade conditions or traffic loads necessitate thicknesses greater than 4 in. (10 cm), it is suggested that the asphalt be placed in two layers. In some cases it may also be necessary to place the mix in

more than one layer to achieve desired smoothness. Three in. (8 cm) of base and 2 in. (5 cm) of surface mix or 4 in. (10 cm) of base and 2 in. (5 cm) of surface are suggested thickness combinations for 5 and 6 in. (13 and 15 cm) total thicknesses.

Small pavers are available but most asphalt paving machines in use today place widths ranging from 8 to 12 ft (2.4 to 3.7 m). Relatively sophisticated self-propelled pavers as well as simpler towed equipment have been successfully used for residential driveway construction.

Whenever possible, hand placement of the mixture should be avoided. However, where access to the driveway site is limited, hand placement may be the only feasible construction method. When the asphalt mixture is placed by hand, it is essential that forms be set at the edge of the driveway. These will ensure a neat edge and will minimize surface imperfections when used as a reference for a strikeoff board.

Weather Conditions

Weather conditions affect asphalt construction. To obtain the best results asphalt paving should be done in warm and dry weather.

Compaction

Compaction of asphalt pavement mixtures is one of the most important construction operations contributing to the proper performance of the completed pavement. That is why it is so important to have a properly prepared subgrade against which to compact the overlying pavement. A steel-wheeled tandem roller is generally used for this type of work. However, many other types of rollers, including small self-propelled vibrating rollers, can be used to obtain the required compaction.

Maintenance

It is not necessary to seal the surface of a newly-constructed asphalt concrete driveway. When the pavement is properly constructed, the driveway should afford many years of service before a thin application of asphalt emulsion driveway sealer containing mineral grit (available at hardware stores) becomes desirable to improve the surface texture and seal small cracks. But, if the pavement is not properly compacted during construction a surface sealer may be needed within two to four years.