Experiences with Thin Bituminous Layers in Austria

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Thin bituminous layers have been used successfully for road maintenance in Austria for several years. Such thin layers are constructed by laying hot-, warm- or cold-mixed material in a thickness of approximately 20 mm on existing asphalt or concrete surfaces. One of the principal applications to date has been the filling of ruts in concrete surfaces caused by studded tires. Technical requirements for thin layers are laid down in an Austrian code of standards. Those standard specifications applicable to the binder, the aggregates, the mixture and the finished layer are discussed and notes on these layers' preparation and application are provided. Recent experiences with thin layers are reported, as is current development work on noise-reducing thin layers. Austria's primary (federal) road network, with a total length of about 12,000 km, includes approximately 5 million m^2 of roadway covered by thin bituminous layers. Of these layers, about 90 percent are hot-mixed layers. Construction costs average about $4.50/sqm. Thin bituminous layers' average service life is an estimated 8 to 10 years.

Thin bituminous layers are wearing courses with thicknesses of up to 20 mm that are applied to bituminous structures or concrete pavements. Their purpose is to increase skid resistance, seal poor bituminous surfaces, and improve transverse evenness, the most important application to date. Structural load-bearing capacity is not increased by such surfacing.

Cold-mixed thin layers, so-called slurry seals, were first applied in Austria in the late 1960s, using cationic emulsions with 200-pen standard bitumen. The results achieved varied, depending on weather conditions, mainly (*1*). This variability is the main reason why slurry seals are not applied extensively on heavily trafficked roads.

First tests with hot-mixed thin layers, based on experiences in Switzerland, date back to the late 1970s. It had become necessary to repair rutting in asphalt and concrete surfaces that was resulting from the use of studded tires. Initially, coated materials containing conventional binders were used, but these did not bond sufficiently to the layer below. At first, some sections of the thin layers peeled extensively after relatively short exposure to traffic. Finally, by using polymer-modified binders in the tack coat and the bituminous mixture, satisfactory results were achieved. In the early 1980s, these results encouraged the use of thin bituminous layers on concrete highways as well. The process has developed on the basis of practical, on-site experiences. The technique was used to repair most of the rutting on Austria's West Autobahn (federal highway A1 from Vienna to Salzburg) and Süd Autobahn (A2 from Vienna to the south). Some of these first maintenance sections are still under traffic today.

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SPECIFICATIONS FOR THIN LAYERS

Specifications to which such thin bituminous layers are constructed in Austria have been derived from practical experience gained during the past 10 years (*2*) and compiled in a code of standards (*3*) to which all federal roads and highways must conform. The code of standards contains specifications for the binder, chippings, grading, mixture, and finished layer as well as details concerning preparation, transportation, and laying of the material.

Binders

For hot-mixed thin layers, only polymer-modified binders may be used; for cold-mixed layers use of these binders is recommended. In Austria, such binders are primarily SBS-modified binders. The need to use polymer-modified binders arises from the more stringent requirements regarding adhesion (adhesion to the chippings) as well as cohesion (a binder's ability to withstand and resist the impact of heavy vehicle trafficking).

Two types of binders are used: hot binders (whereby the mixture is prepared in a mixing plant) and bitumen emulsions (whereby the material is mixed on site). In the latter case, special modified emulsions must be used, to which chemicals are added to extend breaking time.

Use of cut-back bitumen in thin layers, applied in the warm state (100 to 120°C), is in principle permissible, but the practice is decreasing for environmental reasons.

To be suitable for use in thin layers binders must exhibit a broad range between softening- and breaking-point temperatures, high elasticity, and good low-temperature characteristics. Specifications for such binders are summarized in Table 1.

As thin layers may contain a higher proportion of binder than asphalt concrete, there is the risk of a binder draining off hot mixture at higher temperatures. To prevent this, binder carriers are sometimes used that have proved effective at high temperatures and shown to have no detrimental effect on asphalt performance at service temperatures. In Austria, cellulose fibers normally are used; fibers possible alternatives include special fillers, mineral and synthetic fibers.

Aggregates

Aggregates used must also conform to strict requirements. An aggregate's grain shape should be as close to cubic as possible. Badly shaped grains (those with a length-to-width ratio of greater than 3) must not account for more than 10 percent of the total. Edge-holding power must be high, and the Los Angeles coefficient (*5*) not

TABLE 1 Binder Specifications for Thin Bituminous Layers

Parameter	unit	hot mix	cold mix
Softening point (R & B)	°C	> 55	> 43
Penetration at 25°C	1/10 mm	60 to 90	130 to 150
Elastic recovery at 25°C	%	> 70	> 40
Ductility at 25°C (*10*)	cm	> 100	> 100
Breaking point (Fraass)	°C	< -20	< -20
Adhesion between binders and aggregates in water (*4*)	%	> 95	> 95

exceed 18 to 25, depending on the traffic load. Polishability of the aggregates must be low (PSV >50) (*6*). The maximum grain size to be used depends on the application; it will lie between 4 mm and 11 mm. In Austria, most thin layers are built with a maximum grain size of 8 mm.

Grading

The surface of a thin layer must be homogenous and show good skid resistance. It must be even, free from mastic patches, and slightly open graded. This is achieved by reducing fine components in the filler and sand ranges while, at the same time, increasing the proportion of chippings, in particular, that of coarse chippings. A typical mixture might be

	Percent by Weight
Filler (<0.09 mm)	7–9
Sand (0.09 to 2 mm)	18–28
Chippings (> 2 mm)	63–75

Figure 1 shows a typical grading curve for a thin bituminous layer with a maximum grain size of 8 mm. With such mixes, the voids content in the finished layer will lie between 8 percent and 11 percent by volume.

Mix design

Mix composition is determined by tests with different binder contents. For mixtures with an 8-mm maximum grain size, the binder content is approximately 6 percent to 6.5 percent by weight. Optimum binder content is assessed in terms of voids content and marshall stability.

PREPARING AND PLACING THE MIXTURE

When preparing the hot mixture, it is important to ensure that mixing does not take place at temperatures above 180°C. Otherwise the binder will be irreparably damaged, adversely affecting its adhesion to the aggregates. If fibers are added, mixing time will be prolonged by 10 percent to 15 percent, reducing plant capacity.

The hot mixture must be transported in covered trucks in order to prevent excessive cooling of the material. Delivery must be continuous to avoid idle time on the road finisher.

The support to which the thin layer is applied must be clean and dry and have sufficient load-bearing capacity. Any existing cracks must be repaired before the thin layer is applied. Major unevenness must be remedied by a leveling course. Milled areas must be cleaned by a compressed-air or high-pressure water jet.

With such thin layers, good adhesion to the support is especially important to enable the absorption of shear forces and prevent the surface layer from peeling off. The base should be tack-coated before the hot, thin layer is applied in order to secure uniform bonding. The bitumen emulsions used should be modified by the same means used in the preparation of the hot mixture. When the emulsion has broken, the thin bituminous layer is applied by a road finisher working at moderate speed.

If possible, the finisher should not be idle at any time during application. The working speed of the finisher should be coordinated with the deliveries of the hot mix. Compaction preferably is carried out by rubber-wheel rollers. The temperature of the material should lie between 150°C and 170°C during application, and between 120°C and 150°C during compaction. As thin layers cool down very

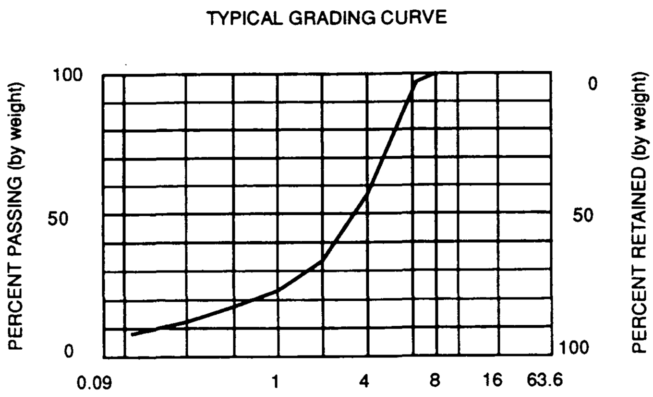

FIGURE 1 Typical grading curve for hot-mixed thin layers with a maximum grain size of 8 mm.

rapidly, efficient rolling is possible only for a few minutes, so rollers must operate immediately behind the finisher. Usually it is not possible to achieve compaction rates of more than 96 percent, but the essential goal is to ensure that the rollers press the layer onto the base in time to secure both good bonding and a good internal structure within the layer.

Final acceptance tests should examine the quality of the raw materials, mixture, thickness of the layer, longitudinal evenness, and bonding of the layer to the support.

Bonding to the support is tested with a special pull-off device (for example, the Schenck-Trebel) that is attached to ring-groove bore holes with a diameter of 50 mm (Figure 2). In the laboratory, it can be attached using cores with a diameter of 100 mm at a temperature of 0°C. The mean value that results from three tests must not be below 1 MPa (*7*).

The warranty period for thin layers made with polymer-modified binders is 3 years. This means that any defects caused by faulty construction that appear during this period must be corrected by the contractor.

Cold application (slurry seals) is carried out with the technique developed in the United States and adopted in Austria. The warranty terms are the same as for hot-mixed thin layers.

EXPERIENCE AND ONGOING DEVELOPMENTS

In Austria's relatively wet climate, applying thin layers by the cold process (slurry seals) is more difficult than laying the hot-mixed material. Furthermore, slurries whose maximum grain size is bigger than 4 mm are rarely used in Austria. For these reasons, cold-mixed thin layers are limited mostly to the secondary highways.

Originally, hot-mixed thin layers were used to rehabilitate old asphalt surface courses in urban areas, as the technique does not require milling the existing surfaces or raising the sidewalks. Hot-mixed thin layers also have been used successfully in overlaying block pavements, provided that a minimum layer thickness of 20 mm over the highest block is ensured and blocks are embedded well enough so that they cannot move. As early as 1980, hot-mixed thin layers were applied to old concrete paved highways on a trial basis. During this time, the entire width of the highway in one direction was overlaid with a thin bituminous layer (*8*).

However, because the need for repairs was limited—rutting in the right-hand lane—a technique was developed in the mid-1980s whereby hot-mixed thin layers could be applied to just one single lane, as had been done previously with slurry seals. The technique uses pavers whose screed can be angled in three sections, making it possible to obtain a "zero" thickness at the edges of a lane. From the hopper and the bar feeders, 0/8-mm material is fed into the middle section of the paver. At the same time, 0/4-mm material is fed into the spreading screws supplying the edge sections of the paver. This action minimizes the step between the new layer on the right lane and the adjacent untreated lane, which prevents damage to the newly laid surface from snow ploughs and ensures adequate transverse drainage, as shown in Figure 3.

Another method used to provide a level transition to untreated lanes consists of laying the thin layer into a bed previously milled to a depth of about 1 to 2 cm, (as shown in Figure 3). This procedure, however, is extremely costly, as milling tools wear out very quickly when used on concrete surfaces made of hard chippings. In addition, milling dust affects the thin layers' bonding to the support layer.

Thin bituminous layers that substantially reduce tire noise have been developed. The so-called "noise-reducing thin surface layers" could be developed because the surface texture of a layer with an 8-mm maximum grain size reduces tire deformation and therefore the vibration of tire casings. In addition, air can escape both through the tire tread and the surface layer without much resistance because the layer's voids content is about 15 percent by volume. In effect, the air-pumping effect is minimized. This development makes hot-mixed thin layers specially suited for use in built-up areas, where the use of thicker noise-reducing surface layers (for example, drainage asphalt) can frequently cause problems.

Overall, an estimated 5 million m^2 of thin bituminous layers have been applied to 12,000 km of Austria's primary (federal) road network. Of these layers, about 50 percent were laid on concrete pavements and 50 percent onto asphalt surfaces. About 90 percent of the layers were hot-mixed, 10 percent cold-mixed.

The extent to which thin layers are used on the secondary road network (provincial and local roads) is very hard to estimate. It may be assumed, though, that hot-mixed layers account for only about 75 percent of the total.

Use of warm-mixed thin layers has been confined to roads in rural areas; however, relevant data are not available.

Estimated mean cost of material per ton laid are as follows:

- AC11 (conventional mix)—$55.00 (100 percent),
- Hot-mixed DDH 8—$75.00 (130 percent), and
- Cold-mixed DDK 8—$175.00 (310 percent).

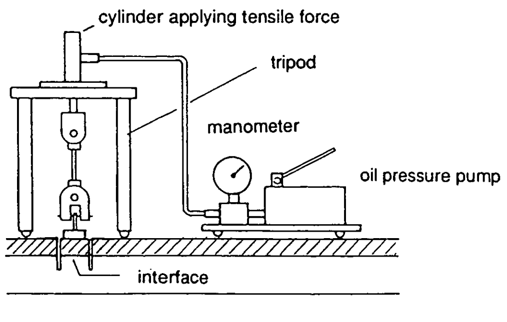

FIGURE 2 Special pull-off device used to test the bonding of layers (field test on ring-groove drilling holes).

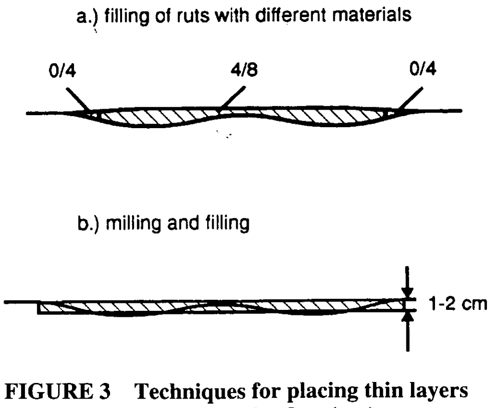

FIGURE 3 Techniques for placing thin layers on the right-hand lane only. One (top) ensures transverse drainage; a second (bottom) provides a level transition to untreated lanes.

Estimated mean cost of finished layer per m^2 of finished layer, including cleaning and tack-coating of the underlying pavement, are as follows:

- Hot-mixed DDH8—$4.50 (100 percent) and
- Cold-mixed DDK 8—$8.00 (190 percent).

Taking into account that, as a rule, cold-mixed thin layers are applied to only one lane, namely the right-hand lane, the cost-per-meter for dual carriageways (motorways) in one direction is the same as for construction of a hot-mixed thin layer covering both lanes.

As mentioned before, to ensure satisfactory performance under traffic it is critical that layers adequately bond with underlying pavement. Therefore, tack coating with a bituminous binder is particularly important.

On cracked pavements, thin layers should be applied only if the cracking was caused by something other than inadequate load-bearing capacity, and if the cracking is confined to the surface course (such as hardening of binder or low-temperature cracking). Experience shows that to successfully use thin bituminous layers on concrete pavements, joints also must be sawn in the overlay and sealed.

In Austria, rutting from abrasion is no longer a significant problem. Even though studded tires are allowed in Austria, their use has declined substantially because of a ban in effect in Germany and a speed limit in Austria.

Experience gained so far suggests the service life of properly constructed thin bituminous layers on a primary road network can be estimated thus:

	Cold-Mixed	*Hot-Mixed*
On asphalt	$\leq$ 10 years	$\geq$ 10 years
On concrete	$\leq$ 8 years	$\geq$ 8 years

The service life of thin bituminous layers on asphalt on a secondary road network can be estimated to be 10 years or longer.

SUMMARY

Austria's experience with thin bituminous layers to date indicates that this method of road maintenance is universally applicable (*9*). Use of high-quality aggregates and suitable binders is a fundamental prerequisite to constructing durable thin layers with an adequate service life, as are careful construction and special attention to ensure their permanent bonding to the supporting layer.

Austria's specification for thin bituminous layers (*3*) is being revised on the basis of the experience gained so far. It is expected that minimum requirements for bonding between the layers will be increased in order to secure good long-term performance.

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Publication of this paper sponsored by Committee on Characteristics of Bituminous-Aggregate Combinations To Meet Surface Requirements.