Technical Bulletin: Cold Weather Paving 1 October 2004

Introduction

The issue of continuing to place Hot Mix Asphalt (HMA) in cold weather comes up every autumn. Projects get delayed. The weather turns cold and damp. Specifications generally set weather and temperature limits beyond which paving is to be stopped; but, jobs often need to be completed in spite of the specification limits. Everyone starts to wonder whether they should continue to pave. The question is "Will HMA pavement placed in cold weather perform adequately?"

A recent industry survey conducted and analyzed by a group of researchers at Auburn University (1) revealed the prevalence of this situation. The responses showed that in the north-central region of the country up to 5% of all projects get placed outside the normal paving season of April to November, and an even higher percentage are placed in adverse weather conditions overall.

The challenge of cold weather HMA paving is to achieve adequate compaction. There is general consensus that, if adequate density is obtained, the pavement will perform as expected. Thin courses and surface courses are at the greatest risk of low density and poor performance when placed in cold weather. Intermediate and base courses greater than 2 inches thick generally can be adequately constructed with little change in normal procedures.

Time for Compaction.

Cold weather compaction depends upon having enough time and enough rollers to obtain adequate density while the temperature of the HMA mix being placed is still within the compaction temperature range, approximately, 275 to 175 degrees F.

What factors affect the time it takes for the HMA to cool below 175 degrees F? All weather factors affect this time: air temperature, wind speed and the presence or absence of sunlight. The type and temperature of the surface on which the HMA is to be placed is a factor too. But, the two most important factors are the temperature of the mix and the thickness of the course being placed. It is generally accepted that, if conditions do not permit 10 minutes of time for compaction, adequate density can probably not be achieved.

It is easy to determine this time for any set of conditions. Dickson and Corlew published cooling curves in 1970 from which you can read the time available for compaction for any given set of ambient and mix conditions. Examples of these charts are shown in the Hot Mix Asphalt Paving Handbook (2). This task became even easier with the development of the PaveCool software by the Minnesota DOT. (download PaveCool at www.mrr.dot.state.mn.us/research/mnroad_project/restools/cooltool.asp) With the PaveCool software one can quickly determine the time available for compaction for any set of conditions and quickly compare the effects of changes in course thickness and mix temperature.

For the conditions specified, the following chart shows the time available for compaction for various combinations of course thickness and mix temperature at placement.

Conditions:

- 30 degrees air and base temperature
- 5 mph wind
- clear and dry
- mid afternoon
- mid- December
- Columbus, OH
- binder grade, PG 64-22
- a single course being placed on an existing asphalt concrete surface,
Example: At a Mix temperature of 275 degrees F, Course thickness 1.25 inches. The time available for compaction is 7 minutes, too short to realistically achieve density. If the mix temperature is raised to 325 degrees F and all others factors are the same, the time available for compaction is 12 minutes. Now you have a chance of getting it compacted before it cools. If the mix temperature is held at 275 degrees F, but the course thickness is increased to 2 inches, the time available for compaction is 17 minutes. It can be readily demonstrated using PaveCool that for any cold weather temperature there is a combination of mix temperature and course thickness that will provide adequate time for compaction.

Contractors responding to the same survey (1) referred to earlier indicated that achieving proper density in cold weather could be difficult, but was not impossible. The other challenge to adequate cold weather construction is economic. Cold weather construction will cost more. Can the extra costs be recovered?

In the following sections of the document we will discuss the changes in procedures needed to obtain durable construction during cold weather and identify extra costs associated with these changes.

**Plant Production**

Mix temperature is one of the most influential factors on time available for compaction. So, an obvious solution is to produce hotter mix. But how much can the mix temperature be raised without causing damage and what is the cost?

Binder suppliers normally recommend a mixing temperature based on viscosity tests. The NAPA publication on Cold Weather Compaction (3) suggests that it is probably safe to mix at a temperature 18 degrees F above the recommended temperature. Above that one risks excessively aging the binder or placing too thin a coating on the aggregates. Raising the mix temperature takes extra fuel and lowers the production capacity of the plant. An examination of the plant production tables in the Hot-Mix Asphalt Paving Handbook (2) indicates that raising the mixing temperature 25 degrees F can reduce the production capacity of the plant by 15% or more. Likewise, increased aggregate moisture contents reduce the production capacity even more dramatically. Given the combination of need for a higher mix discharge temperature and the presence of colder aggregates with higher moisture contents, it is easy to see that the plant production rate may be cut in half to produce mix in cold weather. Stated otherwise, twice as much fuel may be required to produce mix in cold weather.

**Hauling and Temperature Segregation**

The next challenge is to get the mix into the paver with as much of that heat left as possible. The first thought is to tightly tarp the truck beds. However, research (4) has shown that tarping of loads has little effect on the average temperature of the load for normal haul times. So, why bother? This raises the topic of temperature segregation. Temperature segregation is the presence of masses of mix in the mat with temperature differentials that prevent uniform compaction.
When a load is transported in cold weather with
to tightly tarp the loads at least for longer hauls
lacks should not be kept waiting to unload into the
Traffic losses for short hauls will not save much
Tarping losses for short hauls will not significantly raise the
Temperature at which the mix is delivered to the
paver, but may result in a more uniform
temperature mix, thereby minimizing the effect of
temperature segregation.
All of the foregoing speaks to the basic objective in
cold weather paving--keep the total time from
mixing to compaction as short as possible. Haul
trucks should not be kept waiting to unload into the
paver. Minimize the handling and exposure of the
HMA. Windrow paving and transfer devices that
extend the time and further expose the HMA to the
environment should probably be avoided. Move
the material directly from the haul truck as a mass
into the hopper of the paver.

Placement
If the HMA course is to be placed on an aggregate
base, the base must be solidly compacted, at or
below optimum moisture and not frozen. Frozen
or excess moisture saps the heat out of HMA
rapidly and may contribute to soft spots in the
base. If being placed over an existing paved
surface, the surface must be dry and the tack coat
material set. How do you get that slow setting
emulsion tack coat to break and dry in cold, damp
weather? You could use rapid-curing liquid
asphalt for tack, if you can get it. Instances have
been reported where contractors have used jet
racetrack dryers or infrared heaters to dry the
surface before placement of the HMA.
Areas that require handwork or feathering of the
mix can probably not be placed rapidly enough to
permit adequate compaction. Construction of this
type of work must be avoided during cold weather
or considered to be temporary. Construction of
transverse joints must be placed with good
technique, starting off with the screed at the joint
and on starting blocks; so that, time is minimized
and the need for handwork is eliminated. Paver
speed should be regulated to allow the available
rollers to complete compaction within the time and
temperature constraints. Other operations should
follow the best techniques as would be practiced
under any conditions.

Compaction
The goal is to compact the HMA while the mix is
still within the compaction temperature range, 275
to 175 degrees F. The number, type and capacity of the
rollers should be selected to accomplish
adequate compaction within the time available,
based on environmental conditions. More rollers
and higher capacity rollers operating right behind
the paver will be necessary to accomplish the
compaction in the short time available. The use of
rubber tired rollers may be the answer in obtaining
density quickly. However, special care must be
used to heat the tires to prevent mix pickup. Use
the skirts around the tires. Contractors have fitted
heaters within the skirt enclosures to pre-heat the
tires and ducted the engine exhaust inside the
skirt enclosures to keep the tires hot. Silicone
based additives are on the market for mixing into
the water used to prevent mix pick-up on the tires.
The provision of additional rollers and their
operators, heating of tires and special release
additives all represent additional costs of cold
weather paving that must be accounted for.

Specifications and Quality Assurance
Is it worth extra cost and effort to place HMA in
cold weather? Ultimately, only the person paying
the bill can answer that question. If a decision is
made to place the HMA in spite of the cold
temperatures, it usually costs a lot less to do the
job right the first time than it does to do it over.
Research out of Washington State has indicated
that even a few percentage points less density
results in double-digit percentage losses in
durability (life of the pavement). So, if you're the
owner, it probably makes sense to invest the extra
cost to get adequate density, if you absolutely
have to have the work completed in cold weather.

How do you handle the extra cost and payment for
this extra effort? The usual way is by change
order, but scarce, suitable working days can be
lost while such things are negotiated and
processed. If an owner anticipates that such a
situation might occur on his project, it may be
worth while to set up an alternate bid item for the
extra cost of cold weather paving, in order to
establish in advance a price for the extra work needed to adequately place and compact HMA in cold weather. Issues such as changes to course thickness and mix type would have to be addressed and some quality assurance or acceptance measures might have to altered. If the project were to be a density acceptance project (ODOT, Item 446) then the effectiveness of the contractor's compaction procedures would be revealed by the acceptance cores. If, however, the method of acceptance is another basis, such as ODOT 448, then some other measure for verifying the effectiveness of the contractors placement and compaction procedures would have to be established in the specifications. The owner may require the placing of a control or test strip, to ensure that minimum acceptable density results from the contractor's proposed procedures. For information on constructing a control strip, see reference 5.

Summary and Conclusions:

Hot Mix Asphalt paving can be successfully accomplished in cold weather without compromising the performance of the pavement, but costs will be higher. The goal is to obtain adequate time to finish compacting the mix, while it is still in the compaction temperature range (275 to 175 degrees F). Time available for compaction is most dependent upon the temperature of the mix and the thickness of the layer being placed and less dependent upon the environmental conditions. Making adequate time available for compaction can be accomplished by taking steps to alter these dependent variables and to minimize the time of exposure of the mix between mixing and compaction. Specific actions may include any or all of the following as necessary:

- Increase the mix temperature
- Increase the layer thickness
- Minimize the time/length of haul
- Work the rollers as close to the paver as possible
- Use more and/or higher capacity rollers

Handwork and feathering can probably not be adequately performed in cold weather and, so, these operations should be avoided; or, if necessary, the results should be considered as temporary surfaces to be replaced in suitable conditions.

Of course, placing a thin HMA course in cold weather should be avoided, if possible. Placing a relatively thick intermediate course, that can be used as the temporary wearing surface until proper conditions return for placing a thin surface course, will involve little change to construction procedures and little additional risk of poor performance.

All reasonable care has been taken in preparation of this Bulletin. However, Flexible Pavements of Ohio can accept no responsibility for the consequence of any inaccuracy that it may contain.

References:

(1)  Hot Mix Asphalt Pavement Construction in Adverse Conditions - An Industry Survey. Dr. David H. Timm, Dr. Mary Stroup-Gardiner and William E. Barrett, Department of Civil Engineering, Auburn University
(3)  Cold Weather Compaction, NAPA, QIP 118, 1998
(4)  Are Hot-Mix Tarps Effective?, NAPA, IS-77, C.E. Minor, 1981
(5)  Construction of Hot Mix Asphalt Pavements, MS # 22, Asphalt Institute, 2nd Edition