FLEXIBLE PAVEMENTS OF OHIO

An Association for the development, improvement and advancement of quality Asphalt Pavement Construction.

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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.

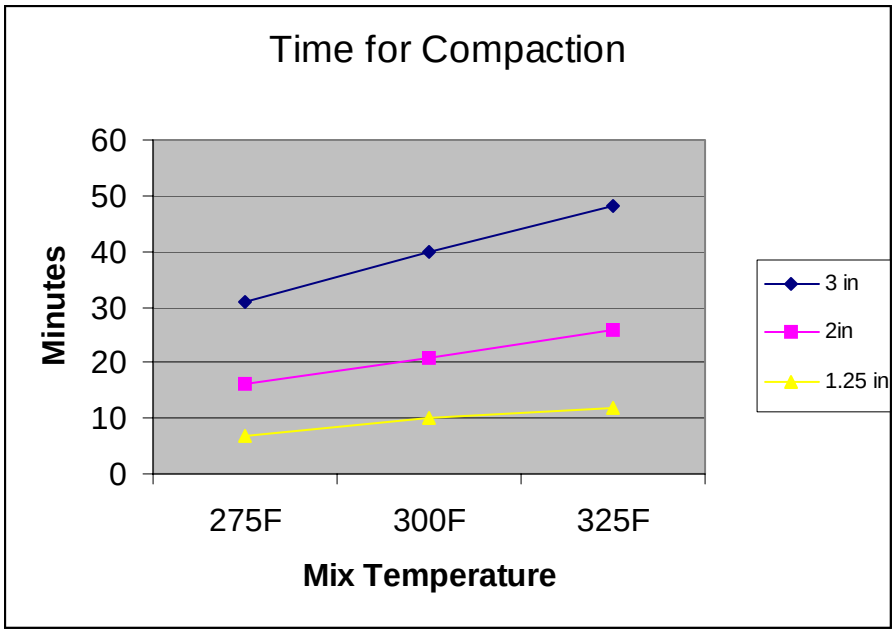
Time for Compaction.

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. (down load 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 out a tarp, the cold crust that forms on the load may be placed through the paver as a cold spot in the mat that cannot be adequately compacted. There is little consensus as to how important this phenomenon is. Some believe this may be an important issue in the performance of pavements, and, as a result , there has been a recent proliferation in equipment for re-mixing material as it is fed to the paver. Others point out that we didn't know about this effect until the advent of the thermal imaging camera. If wasn't a problem before, is it now?

Until this issue is resolved, the recommendation is to tightly tarp the loads at least for longer hauls and to prevent exposure to precipitation. If tarps are used they should tightly cover the load and seal over the sides of the truck bed. Loose, flapping tarps may actually increase heat loss. Tarping loads for short hauls will not save much heat and may take precious time. Tarping loads for longer 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.

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
(2) Hot-Mix Asphalt Paving Handbook, US Army Corps of Engineers, et al, LC 91-74090, James A. Scherocman, Consultant. 1991.
(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