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RAVELING OF HOT-MIX ASPHALT

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Raveling is the progressive separation of aggregate particles in a pavement from the surface downward or from the edges inward. Usually, the fine aggregate wears away first and then leaves little "pock marks" on the pavement surface. As the erosion continues, larger and larger particles are broken free and the pavement soon has the rough and jagged appearance typical of surface erosion.

Due to the versatility of hot-mix asphalt (HMA), paving in cool weather or inclement weather conditions is sometimes mandated. Due to reasons beyond their control, buyers and sellers are at times forced to proceed with construction activities when conditions are less than ideal (i.e. available monies, planning, contract letting, scheduling, utilities, stage construction, access, political action, etc.). HMA mixtures are <u>not</u> injured by freezing weather. As soon as such mixtures are properly compacted to design density, they are finished pavements ready for instant service, regardless of the lower temperature conditions at time of placement.

Asphalt technologists agree that accomplishment of a satisfactory level of compaction (reduced air voids) is a key ingredient in long-term performance. However, HMA placed under adverse conditions requires careful attention and adjustments to ensure a satisfactory end product with reduced surface permeability.

Asphalt pavements placed late in the construction season (late summer or fall) are more susceptible to raveling than those placed early in the construction season because the mixture usually lacks warm weather traffic which partially reduces surface pavement voids, further sealing or densifying the mix. Some geographic areas of the country (particularly the snow belt states/provinces) may be more susceptible to raveling. The ability to resist raveling can vary from mixture to mixture and be dependent upon a multitude of variables. It is not confined to one contractor, one agency nor one state or province. The high probability of raveling not only occurs with late season paving operations, but also in areas where poorer quality aggregates are utilized or when measures are not in place to assure adequate compaction.

MIXTURE AND CONSTRUCTION CRITERIA

Every project for each facility has its' own unique set of circumstances, therefore, mixture constituents and construction activities can vary significantly. Generically, the process is the same – low bid.

Low bid can take the form of an elusive target or a specific measurable quality in construction. Not all HMA is the same even with the same referenced specification criteria. There is also current evidence that laboratory performed HMA design does not adequately predict field characteristics or conditions.

As a minimum, contracts should be prepared or material supplied with an established set of agreed upon end product criteria between the parties involved. Furthermore, test methods should be more specifically defined for the geographic area to alleviate possible cumulative sampling and testing variation. Field verification must be performed during production to establish that the HMA is conforming to design standards with continual quality control and quality assurance as standard operating procedures. Compaction control (corresponding in-place air voids) should be either required or known at the time of construction. In-place density (and, therefore, air voids) is a function of mix design, process plant control, and compaction of the mix.

Specifications for placement of HMA pavements were prepared originally with view to the limitations imposed by hand raking (or luting) and because mixtures cooled during that process. Therefore, many agency specifications insert wordage that work should be done only when the air or surface temperature is above freezing. Recognizing the entirely different conditions brought about by the advent of materials and equipment technology of today, specification appropriateness should be reviewed.

LIKELY CAUSES OF RAVELING

A number of conditions that can lead to raveling are listed by high, medium, or low probability.

High Probability

1. Lack of performance related contract specifications which may contribute to low binder content for the mixture.

2. The facility's intended usage as an interim wear or final wearing surface compared to the "standard" mix.

3. Absorptive aggregates which reduce the effective asphalt content or results in a thinner asphalt film thickness. Absorptive aggregates can be successfully used but testing methods and properties should be addressed at mix design and time of placement.

4. Lack of mix design criterion principles for optimum asphalt-aggregate selection for maximum durability.

5. The ratio of dust (minus #200 sieve materials) to effective asphalt content can be critical. If a project is paved in the fall, when the weather is cooler, the pavement is less workable. The traffic will not have the same kneading and sealing effect. The bituminous pavement may have a higher percentage of voids in its' surface.

6. Lack of field verification of the produced mixture to assure conformance to design criteria (i.e. voids of the mineral aggregate, percent air voids, bulk and maximum specific gravity, asphalt content, etc.).

7. High intensity hydrostatic pressure created by a combination of traffic and water entering the pavement through interconnecting voids, can debond the surface particles. This type of raveling usually occurs from the combination of late season and cool, wet weather soon after construction.

8. The freshly placed hot-mix subjected to inclement weather, moisture or freeze-thaw cycles along with winter maintenance practices very shortly (hours or days) after construction. Most severe areas are intersections, turning lanes, joints, hand work locations, etc.

9. Drainage pattern that allows for surface water to flow through the traffic lane.

Medium Probability

1. Segregated areas in the surface lift where most of the fine aggregate is absent. The coarse aggregates are in contact with each other, but there are minimal contact points where the asphalt cement bonds the aggregate matrix. In time, the asphalt cement may harden; freezing water in the mix voids or traction forces may be high enough to break the individual particles out or cause bond rupture.

2. Over raking, luting, or broadcasting of the HMA during placement operations causing non-uniformity in surface texture.

Low Probability

1. Excess coating of fine dust on the aggregate sufficient enough that the asphalt film adheres to the dust rather than to the aggregate. The horizontal shear stresses on the surface of the pavement resulting from the action of traffic aboard the asphalt film and then dislodge the aggregate.

2. Overheating of the HMA causing the asphalt to become brittle or prematurely hardened. Mixing temperatures should not be higher than 325° F for conventional asphalt.

3. Roller bridging (partial or totally) that restricts optimum uniform densification of the mixture(s).

4. Contamination of the aggregate resulting from unburned fuels used in the HMA plant. Type of burner fuels may change for later season production, therefore, air-fuel adjustments may be warranted. This is not a factor unless heavy fuel is used.

5. Contaminants spilled on the HMA surface may contribute to raveling.

SUGGESTED GUIDELINES TO REDUCE RAVELING POTENTIAL

Considerations, actions and/or procedures to minimize the probability of surface raveling are as follows:

1. Select appropriate construction letting dates, contract requirements and schedules to permit "fair weather" construction practices under desirable conditions.

2. Designers or contract preparers should incorporate realistic mixture criteria for the facility as a specification/contract requirement.

3. Mixture criterion, mix design, process control and compaction requirements should be established to result in an air void system (dense graded) in the mat of approximately 9 percent or less immediately after construction.

4. A stronger emphasis on design, construction, material inspection, equipment calibrations, timely valid testing, production and placement activities rather than after-the-fact testing.

5. The dryer (includes dryer portion of drum-mix plant) should dry the aggregate to provide a moisture content not greater than 0.5 percent as measured behind the placement machine.

$$\text{Percent Mix Moisture} = \frac{100\ (\text{Initial Weight} - \text{Final Weight})}{\text{Final Weight of Mix Sample}}$$

6. Familiarization of standards, specifications, special provisions to strive for more uniformity in judgment and policies.

7. Increased communication with <u>all</u> parties involved throughout the phases of construction.

8. Give strict attention to items that can have a direct impact on performance (i.e. tack coat, weather, road bed temperatures, equipment, longitudinal joints, pavers, paver extensions, vibratory screeds, roller types, volumetric mixture proportions, compaction, paving passes, final pavement marking arrangement, etc.).

9. The base must be firm and, if frozen, should not contain so much moisture as to become unstable upon thawing. However, paving on a frozen base is <u>not</u> encouraged.

10. When the mixture(s) are laid below 40°F atmosphere temperature, loads should be delivered continuously so as to permit immediate consolidation and compaction after spreading.

11. Spreading should be accomplished by mechanical means except for isolated areas.

12. Beware of shaded areas, cool windy conditions, thin lifts, temperature-viscosity relationship for the type and grade of asphalt.

13. Obtain and use temperature and density measure device(s) to establish a rolling zone behind the paver.

14. Where feasible, combine lifts to assure longer mixture heat retention to accomplish density through thicker lifts.

15. Use multiple rollers or a wider roller with a slow continuous placement speed. Rolling in the conventional "train" format is <u>not</u> encouraged (i.e. breakdown, intermediate and finish) for cool weather placement. Continuous rolling, rollers side by side, is preferred.

16. Rolling equipment should be provided in such extra number to ensure rapid consolidation and compaction immediately after spreading and developing required density.

17. If construction schedules dictate cold weather paving, the following is suggested:

    a) Design the asphalt pavement structure with at least two layers so that an interim wearing surface will be used during the first winter. The final wearing course should be placed the following spring (or during better weather) so that if problems develop, it will be confined to a more easily repairable situation prior to completion.

b) Re-evaluate volumetric properties for the facility such as possible reduced air voids (i.e. 3, 3.5 vs. 4), aggregate blend and its effective asphalt content, etc. Consideration should be given to the location of the mix (i.e. shoulder, pathway, parking lot, type of traffic, etc.).

c) Consider a minimum of one pneumatic-tired roller be used in conjunction with an appropriate minimum lay down temperature for compaction.

18. Be aware of possible excess release agent usage on paver aprons, chains, transport vehicles, flushing of pumps and lines.

19. Longitudinal joints between strips should be parallel to the centerline. In multiple lane construction, when the wearing course is constructed in an even number of strips, one longitudinal joint should be on the centerline. When it is constructed in an odd number of strips, the centerline of one strip should be on the centerline of the roadway (facility). **No longitudinal joint should be located in the wheel path area of a wearing surface traffic lane.**

20. Strike-off only extension assemblies should not be allowed for paving wearing course.

21. Open roadway to normal traffic as soon as possible to allow the roadway to be subjected to warm weather and traffic prior to inclement winter conditions.

22. Review snow removal policies, procedures, materials and equipment. This should include the stockpiling of excess snow relative to surface drainage patterns. Do not allow blockage of surface drainage.

23. Surface drainage should be adjusted to minimize the flow of water across or in traffic lanes. The presence of water will aggravate raveling.

24. Develop the expertise for prevention, detection, diagnosis and preventive maintenance action if raveling should start to develop.

It should be realized that in the construction environment, an item which we (buyer and seller) have no control is the weather. Even with adherence to the suggested guidelines presented, raveling could still occur on a project.

REPAIR OF RAVELING

Raveled surfaces, dry and weathered surfaces, and porous surfaces are conditions which usually require a surface treatment. These treatments may be looked upon either as corrective maintenance or as preventive maintenance. In the former case, they are used to correct an existing condition. In the latter, they are used in an effort to prevent an anticipated condition from becoming a reality.

1. **Emergency Repair**
   a) Once detected, keep the surface free of all dirt and loose aggregate material.

b) Review snow removal policies, procedures, materials, equipment and drainage. Do not allow snow and ice to block drainage.

c) A fog seal (treatment) has been very successful and can also be performed during the non-construction season with proper precautions. The type of facility and its usage should be a judicious consideration. Commonly, a light application is used of dilute emulsion or cutback. The road (facility) surface should be dry and clean prior to application.

2. **Pavement Repair**
   a) Same as a), b), and c) for Emergency Repair.

   b) Apply a conventional surface rehabilitation/maintenance technique such as hot-mix thin overlay, sand seal, chip seal, slurry seal or micro-surfacing. Depending upon the ultimate condition at the time of repair, the facility usage and type, the fixed elevations and the material costs in each geographic area, repair strategies will vary.

SUMMARY

Raveling of hot-mix asphalt (HMA) is the eroding away of the surface where water and traffic are present. Pavements placed late in the construction season (late summer or fall) are more susceptible to raveling than those placed earlier in the construction season because the mixture usually lacks warm weather traffic which reduces pavement surface voids, further densification, and kneading of the asphalt mat. The ability to resist raveling (or its cause) can vary from mixture to mixture and be dependent upon a multitude of variables. It is a phenomenon associated more commonly with late season construction, cool ambient air and base temperatures and the presence of moisture/water with traffic action.

The mix criteria, temperature-viscosity relationship of the asphalt material, production process, lift thickness, compaction, in-place air voids and freeze-thaw cycles with moisture present are all possible variables which can contribute to raveling. The weather is an item which we (buyer and seller) have no control, therefore, even under ideal specifications and construction practices, raveling could occur.

The keys to successful late season paving operations are being aware of negative variables, making warranted adjustments, and reducing the associated risks.

If raveling is suspected (buyer or seller), it is advisable to make a site review and closely monitor the project. One should not allow loose material (abraded mix, winter maintenance material, etc.) to remain on the surface for extended periods of time, especially if continued traffic usage and free water/moisture will be present. This will usually cause progression of raveling severity.

In order to more fully appraise the situation, its extent and prior to any rash judgments, a field review later in the spring is highly recommended. A collaborative working spirit will be of utmost importance for project resolution, acceptance, and long term performance expectation in the event raveling is present.