OHIO
ASPHALT

Preventing And Correcting Rutting In Asphalt Pavements

In recent years, changes in the mix types and layer thicknesses used by the Ohio Department of Transportation (ODOT) have nearly eliminated rutting on its freeway system. Yet rutting is still sometimes observed on other roads and streets, especially at what we call high-stress locations (i.e., intersections, grades, any places where heavy vehicles stop, start, turn or climb steep grades). These types of pavement defects need not be tolerated, as the asphalt pavement technology exists to prevent or correct such problems.

Why Pavements Deform

Prevention or correction begins with an understanding of the types and causes of pavement deformation. There are four types of rutting, or as it is sometimes known as channelization:

- Mechanical deformation or subgrade displacement of the asphalt pavement
- Plastic deformation of the asphalt mixtures near the pavement surface
- Consolidation or the continued compaction under the action of traffic
- Surface wear, the actual wearing away of surface particles by traffic

While the specific mode of failure must be determined before selecting a solution, this article focuses on the issue of plastic deformation and the prevention or correction of plastic deformation failures.

Before attempting to correct these defects it is necessary to conduct an investigation to verify the type of deformation present

Plastic Deformation is a material failure of the asphalt concrete. The mix is displaced from under the tires and typically humps up outside the wheel tracks. Plastic deformation sometimes appears as shoving or corrugations in the pavement as well as rutting. A cross-section of a pavement exhibiting plastic flow deformation will typically look like Figure 1.

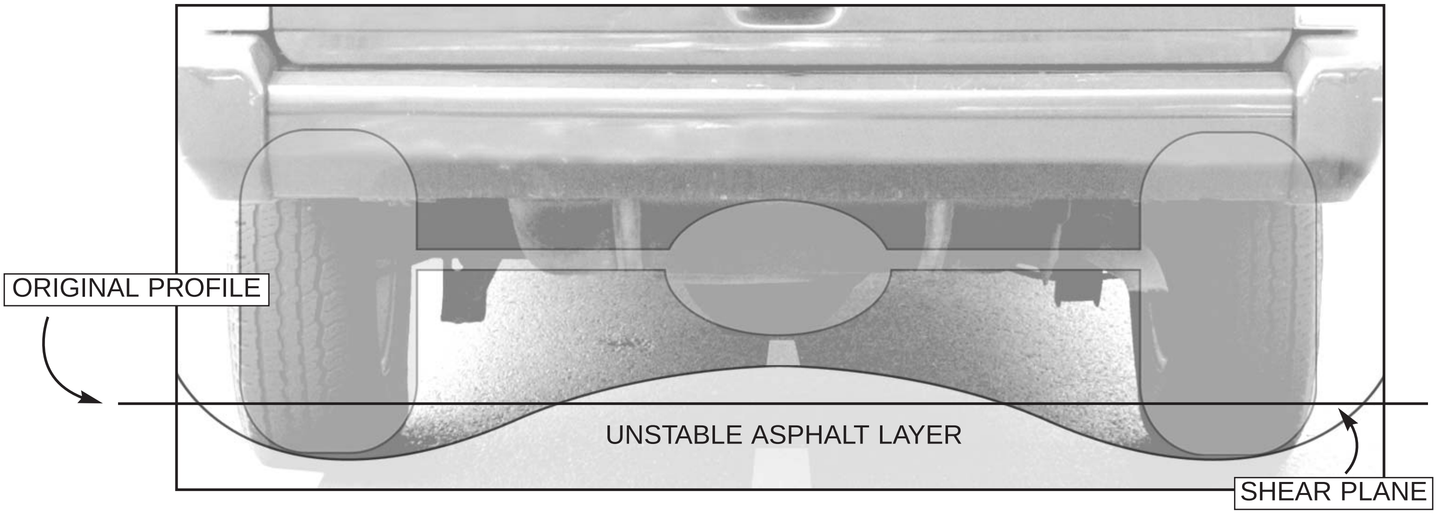


Fig. 1 When Plastic deformation occurs to asphalt concrete the mix is displaced from under the tires and typically humps up outside the wheel tracks.

In the case of plastic deformation, the mix lacks the internal strength to resist permanently deforming under the stress imposed by the loaded vehicle tires. The internal strength of the mix is affected by the friction characteristics of the aggregates, especially the fine aggregate, and the visco-elastic properties of the asphalt binder. Angular aggregates have higher internal friction to help resist deformation under load. Stiffer or more elastic binders resist becoming sufficiently viscous at high pavement temperature to allow the pavement to deform under constant or slowly moving loads. In addition, the two materials must be combined in the optimum proportions through a rigorous mixture-design procedure that ensures the proper air voids are incorporated in the compacted mixture. Excess asphalt content will enable plastic deformation within the mix.

Prevention of plastic deformation depends on specifying mixtures that are properly designed. Mixtures must have an adequately angular aggregate structure, and have a grade of asphalt binder that is sufficient to resist flow at the expected high pavement temperatures and loading conditions. Consideration must be given to both magnitude of load and speed of loading.

Correction of a plastic deformation condition will usually consist of removing all the deformed asphalt concrete and replacing it with material that is adequately stable to resist the stress and temperature conditions.

Determining the Mode of Failure

Before attempting to correct these defects it is necessary to conduct an investigation to verify the type of deformation present. This investigation may be as simple as a visual inspection on small and relatively low-cost projects, all the way up to an extensive program of sampling and testing. There are several methods that may be used.

Trenching is the most effective method to determine the cause of rutting. In this method, parallel, transverse, full-depth saw cuts are made across the pavement, and the intervening material is removed to expose the full cross-section of the pavement. It is then straightforward to identify the deforming pavement layers

Fig. 2
Cores taken from an overlay on a brick pavement show 2 1/2 inches of rutting in a nominal 4 1/2-inch-thick, three-course overlay. All three asphalt layers were deformed, with the greatest deformation in the bottom, Type 2, layer.

and determine the mode of failure. In the case of plastic deformation, it is usually possible to identify which individual pavement layers are deforming. The correction of plastic deformation involves removing all of the asphalt material to a depth that includes the deformed layers, and replacing it with stable mix.

Where trenching is not feasible, it is usually possible to make the same determination from cores. In this method, cores are taken across the rutted lane at the points of maximum rut and at maximum heave and at relatively un-deformed areas for comparison of the layers. The surface of the cores should be referenced in elevation so that the deformation can be accurately plotted. By using the surface elevations of the cores, and measuring the visible layers in the cores, it is possible to graphically represent the cross-section of the pavement, determine the mode of failure and identify the deforming layers. Figure 2 is an example of cores taken across a rutted lane.

An analytical method for determining the mode of failure was developed under the National Cooperative Highway Research program (NCHRP) project 1-34A (1) by researchers Thomas White and John Haddock at Purdue University. This method uses the numbers from a measured transverse-surface profile to calculate coefficients that indicate the mode of failure. This method may be most useful where destructive methods of testing are not feasible. Details of the analysis method can be found in the Appendix of the reference. (1)

[Correcting rutting in asphalt overlays over concrete pavement presents special challenges]

Treatments to Prevent or Correct Plastic Flow Deformation

As previously stated, correction of a plastic flow failure involves removing all the deforming pavement layers and replacing them with mix that is designed to withstand the high stresses without deformation. If a forensic investigation has been performed, the affected layers will have been identified through that process. Where such an investigation is not warranted or feasible, the "rule of thumb" is to place four inches of stable material. It is generally accepted that most plastic deformation occurs in the top four inches of the pavement. However, forensic investigations have occasionally documented deformation occurring deeper. Thus, there is some risk involved in using the "rule of thumb" as it is usually not possible to stop rutting by placing stable material over deforming material. ODOT's manual (2) recommends planing the rutted pavement to a depth of three inches below the deepest point of the rut.

Correcting rutting in asphalt overlays over concrete pavement presents special challenges. The interface between a thin asphalt overlay and a concrete surface can be a shear plane where stresses concentrate. It is not uncommon for asphalt concrete overlays to shove on the surface of the concrete, exacerbating the problem of rutting. If the forensic investigation does not reveal that at least 2 inches of stable material can remain on the concrete after milling all of the deformed material, then, the recommended treatment in these cases is to mill off the asphalt overlay. To provide some mechanical interlock for the surfacing materials, milling should scarify, or roughen, the concrete surface. Prior to placing the new asphalt overlay, a rubberized tack coat, Item 702.13, is usually used on concrete to improve adhesion.

Choosing Rut-Resistant Materials

There are several options in ODOT's Specifications (3) for materials that will stand up in high-stress applications. Item 441, Asphalt Concrete, Type 1H or Item 442, Superpave Asphalt Concrete, Type B, 12.5 mm are generally adequately stable for high-stress locations on roads and streets having moderate volumes of heavy trucks. By ODOT specification, these mixes incorporate a polymer modified binder, performance grade PG 70-22M for the surface course only. For use in high-stress locations we recommend that the amount of polymer modification be increased by specifying PG 76-22M (per SS 908) for both the surface and intermediate courses. For economy on smaller projects, we suggest placing the same material as both the intermediate and surface course. These mixes can be placed as thin as 1.5 inches; however, on a high-stress application we suggest placing two, 2-inch-thick courses to achieve a 4-inch build-up of rut-resistant mix. On large projects the intermediate course could be a 441, Type 2, Heavy or a 442, Type B, 19 mm, both with PG 76-22M binder placed at least 1.75-inches thick for economy.

On new construction, the designer must determine the extent of the pavement to receive a special high-stress treatment. ODOT (2) recommends at least 250 feet back from the stop termini at an intersection. If a number of high-stress locations exist in close proximity, it is probably most economical to treat the entire project area with the more rut-resistant mix.

For roads and streets having high volumes of heavy trucks, tougher material is needed. Item 442, Superpave Asphalt Concrete, Type A uses all crushed aggregates for both the coarse and fine-aggregate portions of the mix. These mixes can be expected to have greater stability than the Type B mixes. The binder recommendation is the same, PG 76-22M. When specifying Item 442 mixes for high-stress locations, specify a design compaction level (Ndes) of 100 gyrations. The ultimate mix for resisting deformation and ensuring longevity is, however, specified under Supplement Specification (SS) 856, Stone Mastic Asphalt Concrete. Use PG76-22M binder for both the surface and intermediate courses.

These are not the only possibilities for treating high-stress locations. For lighter-traffic applications, it may be sufficient to modify the standard mix by the upgrade to a polymer modified binder. ODOT's Supplemental Specification SS 908 makes this simple by defining two polymer-modified binder grades, PG 70-22M and PG 76-22M. For very small projects other options include modified standard mixes that incorporate polyester fibers, SS 826 or Gilsonite, SS 857. Our "rule of thumb" recommendation is summarized in Table 1:

Table 1: Conventional asphalt pavement course and material treatments for high-stress locations:

Thickness	Material Specifications
1 3/4 in. Minimum 2 1/4 in. Recommended	Item 442, asphalt concrete intermediate course, 19 mm, Type A or B, (446) Ndes = 100, PG 76-22M
1 1/2 in. Minimum 1 3/4 in. Recommended	Item 442, asphalt concrete surface course, 12.5 mm, Type A, (446), Ndes = 100, PG 76-22M

Note: PG and polymer-modified binders per SS 908
All specification references are to the 2002, ODOT, CMS (3)

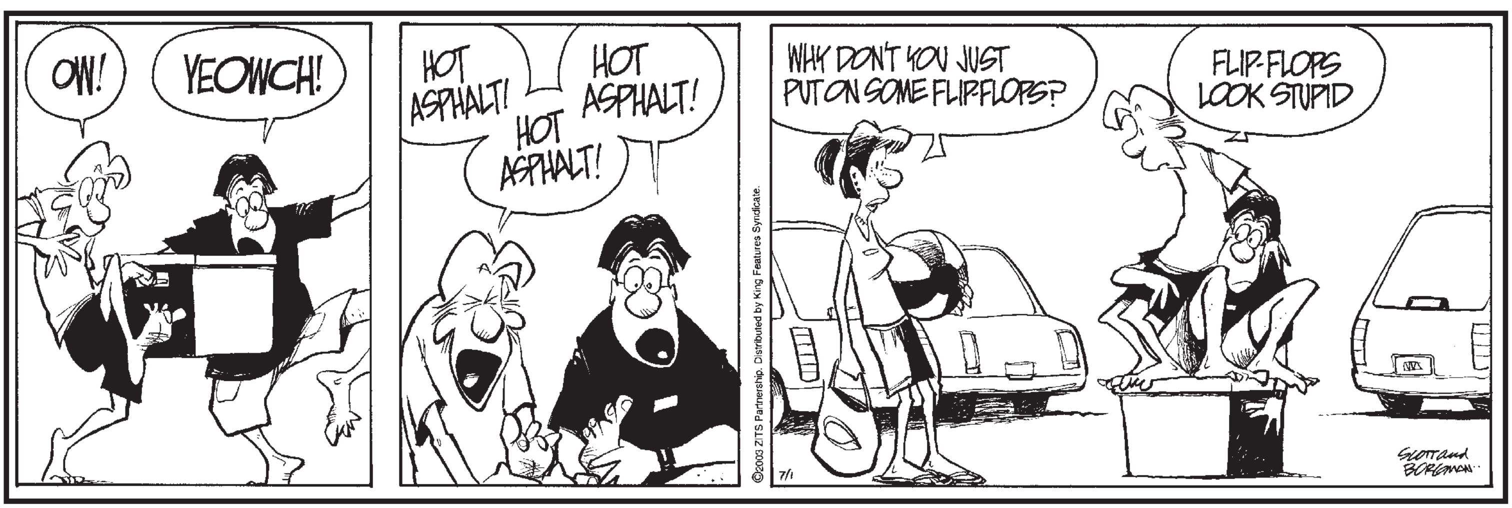
Summary
The solutions for preventing rutting deformation in new pavement construction and for correcting existing deformed pavements are readily available. The solution includes ensuring adequate structural capacity of the pavement, determining the mode and extent of the failure or area requiring special treatment, and in specifying appropriately rut-resistant materials for the anticipated traffic type.

References:

1) *NCHRP Report 468,*

2) *Pavement Design and Rehabilitation Manual, Ohio Department of Transportation, 1999.*

3) *State of Ohio, Department of Transportation, Construction and Material Specifications, Ohio Department of Transportation, 2002*



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