CHAPTER 11
PRINCIPLES OF DESIGN FOR FLEXIBLE PAVEMENT INTERSECTIONS

11.1 Introduction

A standard pavement design is based on fast-moving traffic traveling one direction on long stretches of roadway where drainage is usually easy to handle. This is not the situation with intersections. Traffic loadings are greater at intersections because of compounding traffic directions. Also, it's necessary to design for slower stop-and-go traffic, which induces much heavier stresses on the pavement section. In addition, drainage is often compromised within intersections, leading to saturation of the pavement section and the underlying subgrade. Some mixes with a history of good performance may not perform well in intersections, climbing lanes, truck weigh stations, and other slow-speed areas. Special attention should be focused on high traffic volume intersections to ensure the same outstanding performance.

The key to achieving this desired performance is recognizing that these pavements may need to be treated differently than conventional roadways. Specifically, the pavement must be designed and constructed to withstand the more severe conditions. Well-designed, properly constructed HMA intersections provide an economical and long-lasting pavement.

11.2 Design Considerations

Determining whether to use a high performance HMA intersection design versus a conventional HMA design should be assessed on a project-by-project basis. Some general rules to consider are as follows:

- **Intersections with Heavy Truck Traffic and High Traffic Volumes:** If the traffic loading for a 20-year design is a historic designation of one to three million ESALs or greater, a high performance asphalt intersection should be considered. When 20-year traffic loading of the two traffic streams have a historic designation of one million ESALs or greater within an intersection, a high performance intersection design should be considered. If high traffic volume intersections are within ¼ mile of each other, the entire roadway should be designed using a high performance intersection design. Acceleration and deceleration lanes should be included as part of the intersection design.

- **Sharp Turns with Slow-Moving Traffic:** Should be included as part of the intersection design. If there are not enough high performance intersections within a project to warrant a high traffic volume intersection design throughout, but if the intersections within the project are potentially subject to moderate to heavy traffic (historic designation of one million ESALs or greater), they should be blocked out and a high traffic volume intersection design used. When there is two-way traffic, the transition should extend at least 300 linear feet on either side of the intersection. When there is one-way traffic, the transition should be at least 300 linear feet on the

deceleration side and 100 linear feet on the acceleration side of the intersection. The definitions and design factors necessary for flexible pavement design were introduced in previous sections.

- It is suggested a PG 76-28 binder be selected for asphalt intersections, providing it is available. In general, it is suggested the Superpave™ procedure be followed to select appropriate binder grade for asphalt intersection design.

11.3 Design Period

The destructive effect of repeated wheel loads is the major factor that contributes to the failure of highway pavement. Since both the magnitude of the load and the number of its repetitions are important, a provision is made in the design procedure to allow for the effects of the number and weight of all axle loads expected during the design period. **The design period for new flexible pavement construction and reconstruction is at least 20 years. The design period for restoration, rehabilitation and resurfacing is 10 years**. The selection of a design period less than 10-years needs to be supported by a LCCA or other overriding considerations.

11.4 Traffic Analysis

The destructive effect of repeated wheel loads is the major factor that contributes to the failure of highway pavement. Design traffic will be the historic 18,000-pound equivalent single axle load (18k ESAL) obtained from the CDOT's Traffic Analysis Unit of the Division of Transportation Development. The following website may assist the user in calculating an ESAL value http://dtdapps.coloradodot.info/otis. The actual projected traffic volumes for each category are weighted by the appropriate load equivalence factors and converted to a cumulative total historic 18k ESAL number to be entered into the flexible pavement design equation. The designer must inform the DTD Traffic Analysis Section that the intended use of the historic 18k ESAL is for flexible pavement design since different load equivalence factors apply to different pavement types. Cross traffic at intersections needs to be accounted for as part of the traffic count projection. Use only high quality aggregates. Select the SuperPave™ Gyratory design compaction effort one level higher than would be selected for normal roadway design. If a comparison of flexible and rigid pavements is being made, historic 18k ESALs for each pavement type must be requested. Another source of traffic load data can be weigh-in-motion data. Although these devices are not as plentiful, they are usually more accurate for measurements of traffic load in the present year. Projections for future traffic loads can be calculated similarly using growth factors provided by the DTD Traffic Analysis Unit.

11.5 Design Methodology

Design methodology for flexible intersections are similar to those found in **CHAPTER 6, Principles of Design for Flexible Pavement**.

11.6 Assessing Problems with Existing Intersection

A successful intersection rehabilitation project is dependent on proper project scoping. The keys to proper scoping are the following:

- Identifying the problem with the existing intersection
- Removing enough of the pavement section to encompass the entire problem
- Designing and reconstructing with a high performance hot mix asphalt mix design especially formulated for high traffic volume intersections.

11.7 Performance Characteristics of Existing Intersections

The AASHTO Joint Task Force on Rutting (1987) identified three types of rutting.

- Rutting in base (see **Figure 11.1 Rutting in Subgrade or Base)**
- Plastic flow rutting (see **Figure 11.2 Plastic Flow**)
- Rutting in asphalt layer (see **Figure 11.3 Rutting in Asphalt Layer**)

Figure 11.1 Rutting in Subgrade or Base shows how a weak subgrade or base will expedite damage in all pavements.

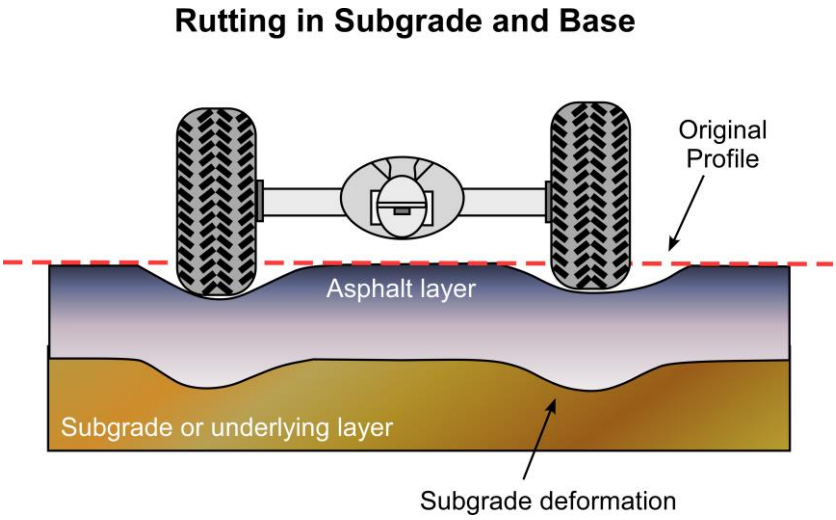

Figure 11.1 Rutting in Subgrade or Base

Figure 11.2 Plastic Flow shows how plastic flow can result for various reasons that include the following:

- High pavement temperatures
- Improper materials and mixture design
- Rounded aggregate
- Too much binder and/or filler
- Insufficient or too high of VMA

Plastic flow or deformation in the asphalt layer occurs during warm summer months when pavement temperatures are high. At intersections, stopped and slow moving traffic allow exhaust to elevate asphalt surface temperatures even higher. Dripping engine oil and other vehicle fluids are also concentrated at intersections and tend to soften the asphalt. A properly designed mixture with a stiffer asphalt binder and strong aggregate structure will resist plastic deformation of the hot mix asphalt pavement.

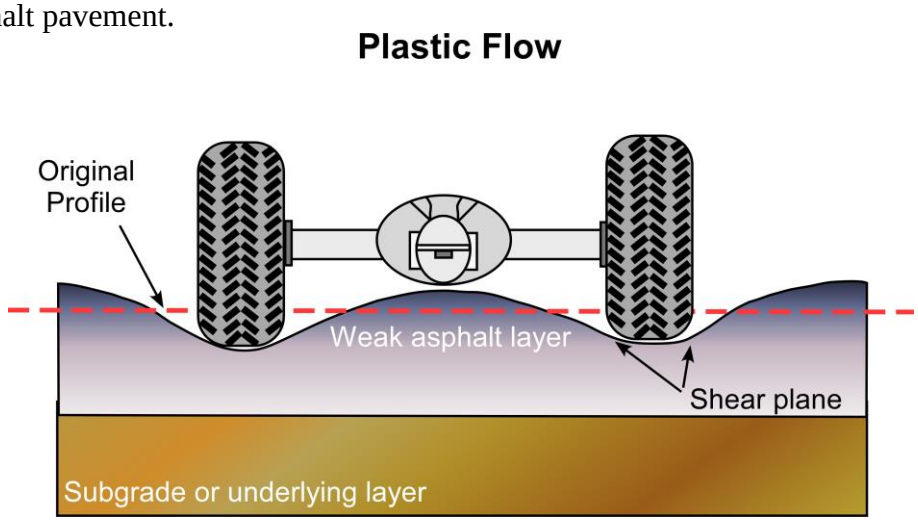

Figure 11.2 Plastic Flow

Figure 11.3 Rutting in Asphalt Layer shows HMA consolidation in the wheel paths. Proper compaction procedures and techniques will ensure the target density is achieved. Good quality control in the design and production of asphalt mixtures is crucial to prevent rutting in the asphalt layer. Consolidation occurs in the wheel paths due to insufficient compaction of the pavement section.

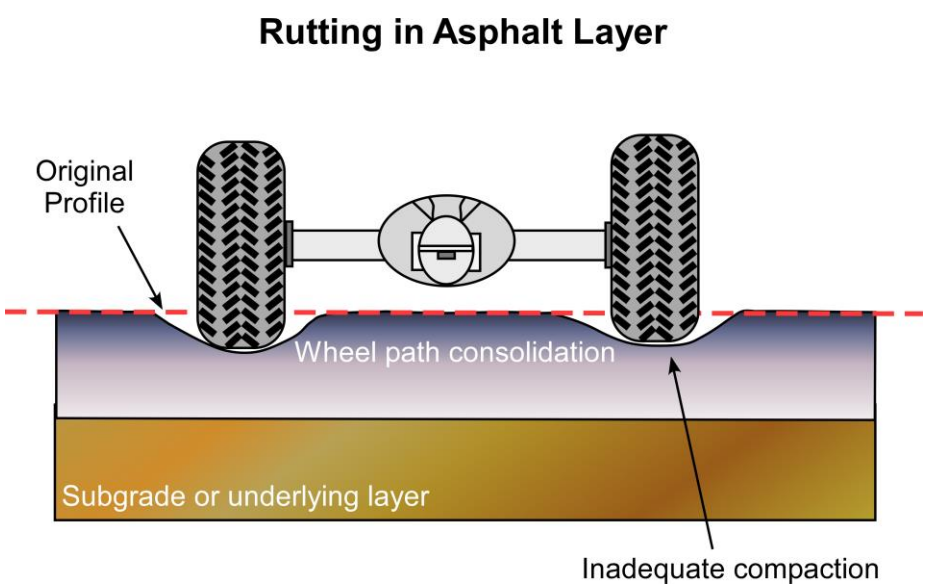

Figure 11.3 Rutting in Asphalt Layer

The following factors can contribute to lack of compaction:

- Insufficient compaction effort within the lower base layers of the pavement section
- Too few roller passes during paving
- Hot mix asphalt material cooling prior to achieving target density
- High fluid content (asphalt moisture, dust)
- Too low of an asphalt content
- Lack of cohesion in the mix, tender mix, and gradation problem with the mix can make it hard to compact

Surface wear is the result of chains and studded tires wearing away the road surface in winter.

11.8 Utilities

Whether it be intersection rehabilitation or new construction, a utility study should be performed to determine if utilities being proposed, or those that are already installed, are adequate in size to handle the projected growth within their service area. It should be verified that existing utilities have been installed properly and utility trenches have been backfilled and compacted properly.