

CHAPTER 2

ASPHALT CONCRETE MIXTURES

Mix design methods and design requirements form an essential part for all asphalt concrete mixtures. The agency or authority responsible for paving construction (Department of Transportation) usually establishes the mix design method and design requirements. Once these are established, it becomes the responsibility of the Contractor/Producer and his technician to develop the mix within the framework of the specification requirements. This section will discuss asphalt mixture properties and types of asphalt mixtures used for highway construction.

An asphalt concrete mixture must be designed, produced and placed in order to obtain the following desirable mix properties: 1) Stability, 2) Durability, 3) Impermeability, 4) Workability, 5) Flexibility, 6) Fatigue Resistance, and 7) Skid Resistance.

Stability

Stability of an asphalt pavement is its ability to resist shoving and rutting under loads (traffic). A stable pavement maintains its shape and smoothness under repeated loading; an unstable pavement develops ruts (channels), ripples (washboarding or corrugation) and other signs of shifting of the mixture.

Because stability specifications for a pavement depend on the traffic expected to use the pavement, the requirements can be established only after a thorough traffic analysis. Stability specifications should be high enough to handle traffic adequately, but not higher than traffic conditions require. Too high a stability value produces a pavement that is too stiff and therefore less durable than desired.

The stability of a mixture depends on internal friction and cohesion. Internal friction among the aggregate particles (interparticle friction) is related to aggregate characteristics such as shape and surface texture. Cohesion results from the bonding ability of the binder. A proper degree of both internal friction and cohesion in a mix prevents the aggregate particles from being moved past each other by the forces exerted by traffic. In general, the more angular the shape of the aggregate particles and the more rough their surface texture, the higher the stability of the mix will be. Where aggregates with high internal friction characteristics are not available, more economical mixtures using aggregate with lower friction values can be used where light traffic is expected.

The binding force of cohesion increases with increasing loading (traffic) rate. Cohesion also increases as the viscosity of the binder increases, or as the pavement temperature decreases. Additionally, cohesion will increase with increasing binder content, up to a certain point. Past that point, increasing binder content creates too thick a film on the aggregate particles, resulting in loss on interparticle friction. Insufficient stability in a pavement has many causes and effects.

Durability

The durability of an asphalt pavement is its ability to resist factors such as changes in the binder (polymerization and oxidation), disintegration of the aggregate, and stripping of the binder films from the aggregate. These factors can be the result of weather, traffic, or a combination of the two. Generally, durability of a mixture can be enhanced by three methods. They are: using maximum binder content, using a dense gradation of stripping-resistant aggregate, and designing and compacting the mixture for maximum impermeability.

Maximum binder content increases durability because thick binder films do not age and harden as rapidly as thin ones do. Consequently, the binder retains its original characteristics longer. Also, maximum binder content effectively seals off a greater percentage of interconnected air voids in the pavement, making it difficult for water and air to penetrate. Of course, a certain percentage of air voids must be left open in the pavement to allow for expansion of the binder in hot weather.

A dense gradation of sound, tough, stripping-resistant aggregate contributes to pavement durability in three ways. A dense gradation provides closer contact among aggregate particles. This enhances the impermeability of the mixture. A sound, tough aggregate resists disintegration under traffic loading; and stripping-resistant aggregate resists the action of water and traffic, which tend to strip the binder film off aggregate particles and lead to raveling of the pavement. Under some conditions, the resistance of a mixture to stripping can be increased by the use of antistripping additives, or a mineral filler such as hydrated lime. Designing and compacting the mixture to give the pavement maximum impermeability minimizes the intrusion of air and water into the pavement. A lack of sufficient durability in a pavement can have several causes and effects.

Impermeability

Impermeability is the resistance of an asphalt pavement to the passage of air and water into or through it. This characteristic is related to the void content of the compacted mixture, and much of the discussion on voids in the mix design sections relates to impermeability. Even though void content is an indication of the potential for passage of air and water through a pavement, the character of these voids is more important than the number of voids. The size of voids, whether or not the voids are interconnected, and the access of the voids to the surface of the pavement all determine the degree of impermeability. Although impermeability is important for durability of compacted paving mixtures, virtually all asphalt mixtures used in highway construction are permeable to some degree. This is acceptable as long as it is within specified limits.

Workability

Workability describes the ease with which a paving mixture can be placed and compacted. Mixtures with good workability are easy to place and compact; those with poor workability are difficult to place and compact. Workability can be improved by changing mix design parameters, aggregate source, and/or gradation.

Harsh mixtures (mixtures containing a high percentage of coarse aggregate) have a tendency to segregate during handling and also may be difficult to compact. Through the use of trial mixes in the laboratory, additional fine aggregate and perhaps binder, can be added to a harsh mix to make it more workable. Care should be taken to ensure that the altered mix meets all other design criteria, such as void content and stability. Too high a filler content can also affect workability. It can cause the mix to become gummy, making it difficult to compact. Workability is especially important where quite a bit of hand placement and raking (luting) around manhole covers, sharp curves, and other obstacles is required. It is important that mixtures used in such areas are highly workable.

Mixtures that can be too easily worked or shoved are referred to as tender mixes. Tender mixes are too unstable to place and compact properly. They are often caused by a shortage of mineral filler, too much medium-sized sand, and smooth, rounded aggregate particles, and/or too much moisture in the mix. Although not normally a major contributor to workability problems, the asphalt binder does have some effect on workability. Because the temperature of the mix affects the viscosity of the binder, too low a temperature will make a mix unworkable, too high a temperature may make it tender. Binder grade may also affect workability, as may the percentage of binder in the mix.

Flexibility

Flexibility is the ability of an asphalt pavement to adjust to gradual settlements and movements in the subgrade without cracking. Since virtually all subgrades either settle (under loading) or rise (from soil expansion), flexibility is a desirable characteristic for all asphalt pavements. An open-graded mix with high binder content is generally more flexible than a dense-graded, low binder content mix. Sometimes the need for flexibility conflicts with stability requirements, so that trade-offs have to be made.

Fatigue Resistance

Fatigue resistance is the pavement's resistance to repeated bending under wheel loads (traffic). Research shows that air voids (related to binder content) and binder viscosity have a significant effect on fatigue resistance. As the percentage of air voids in the pavement increases, either by design or lack of compaction, pavement fatigue life (the length of time during which an in-service pavement is adequately fatigue-resistant) is drastically shortened. Likewise, a pavement containing binder that has aged and hardened significantly has reduced resistance to fatigue.

The thickness and strength characteristics of the pavement and the supporting power of the subgrade also have a great deal to do with determining pavement life and preventing load-associated cracking. Thick, well-supported pavements do not bend as much under loading as thin or poorly supported pavements do. Therefore, they have longer fatigue lives.

Skid Resistance

Skid resistance is the ability of an asphalt surface to minimize skidding or slipping of vehicle tires, particularly when wet. For good skid resistance, tire tread must be able to maintain contact with the aggregate particles instead of riding on a film of water on the pavement surface (hydroplaning). Skid resistance is typically measured in the field at 40 mi/hr with a standard tread tire under controlled wetting of the pavement surface. A rough pavement surface with many little peaks and valleys will have greater skid resistance than a smooth surface. Best skid resistance is obtained with rough-textured aggregate in a relatively open-graded mixture with an aggregate of about 3/8 in.-1/2 in. (10-13 mm) maximum size. Besides having a rough surface, the aggregates must resist polishing (smoothing) under traffic. Calcareous aggregates polish more easily than siliceous aggregates. Unstable mixtures that tend to rut or bleed (flush asphalt to the surface) present serious skid resistance problems.

Mixture Types used in Virginia

There are many types of asphalt concrete mixtures used in highway construction. In Virginia however, there are three basic types- Surface mixes ("SM"- Type), Intermediate mixes ("IM" - Type), and Base mixes ("BM" - Type). Section 211 discusses each type in more detail, but note that each type has a specific purpose and location within an asphalt concrete pavement structure.

The basic requirements in building a road for all-weather use by vehicles are to prepare a suitable subgrade or foundation (with proper density), provide necessary drainage, and construct a pavement that will:

1. have sufficient total thickness and internal strength to carry expected traffic loads;
2. prevent the penetration or internal accumulation of moisture; and
3. have a top surface that is smooth, skid resistant, and resistant to wear, distortion, and deterioration by weather and deicing chemicals.

The subgrade ultimately carries all traffic loads; therefore, the structural function of a pavement system is to support the wheel loads on the pavement surface and to transfer and spread these loads to the subgrade without exceeding the support capability of the subgrade material or over-stressing the pavement components. A flexible pavement structure consists of all asphalt concrete courses or layers above the prepared subbase or subgrade (Figure 2-1).

Surface mixes (“SM” - Type)

The upper most layer of the pavement structure is called the surface or wearing course. This course or layer is usually composed of a “SM” type mix.

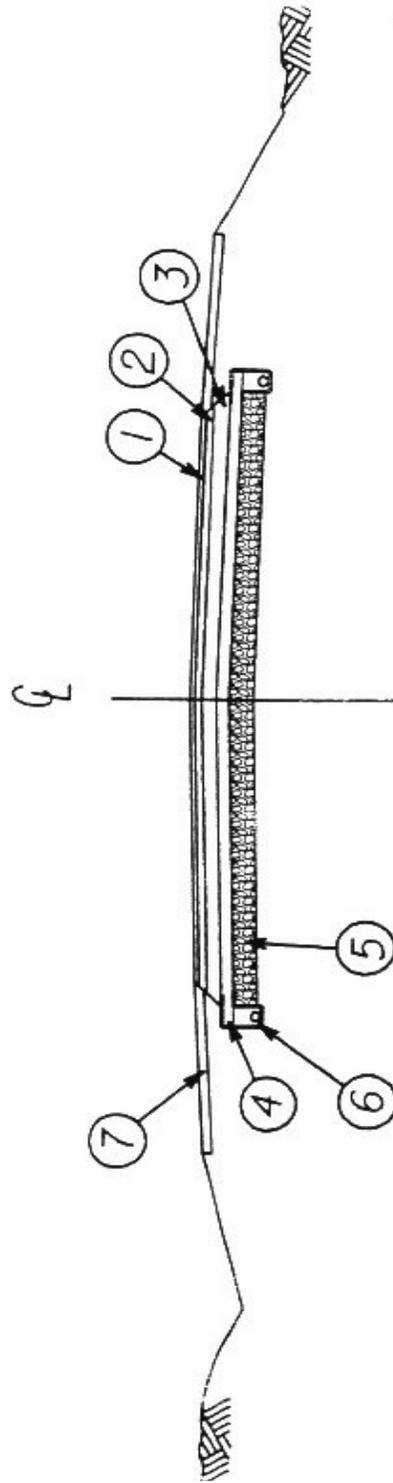
Intermediate mixes (“IM” - Type)

In special cases where added strength is needed in the pavement structure, “IM” type mixes are sometimes used in the surface course. This binder or intermediate course is composed of an “IM” type mix.

Base mixes (“BM” - Type)

The base course is placed immediately below the surface course (or binder course if a binder course is found to be necessary) and is composed of a “BM” type mix. The base course is the structural strength element of the asphalt concrete pavement system. This layer distributes the wheel loads over the subbase and subgrade.

Typical Section For Flexible Pavement



Structural Design Terms

1. Surface Course
2. Intermediate Course
3. Base Course
4. Drainage Layer
5. Subbase Course
6. Underdrain (UD)
7. Shoulder

Typical Flexible Pavement
Figure 2-1

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Study Questions

1. The frictional resistance of the surface of the pavement to insure safe driving and stopping of the vehicle is called:
 - A. durability
 - B. stability
 - C. flexibility
 - D. skid-resistance

2. The ability of the asphalt pavement to withstand repeated flexing or slight bending caused by the passage of wheel loads is called:
 - A. ductility
 - B. fatigue resistance
 - C. flexibility
 - D. variability

3. The resistance to the effects of traffic, water, air, and temperature changes is known as:
 - A. durability
 - B. flexibility
 - C. variability
 - D. ductility

4. The ability of a pavement to adjust itself to settlement of the base without cracking is known as:
 - A. impermeability
 - B. stability
 - C. workability
 - D. flexibility

5. The ease with which the material can be placed to the desired uniformity and compacted to the required density is known as:
 - A. viscosity
 - B. stability
 - C. workability
 - D. flexibility

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Study Questions (continued)

6. Type SM-12.5A asphalt concrete is a:
 - A. base course mix
 - B. surface course mix
 - C. binder course mix
 - D. cold mix

7. Four physical properties that are required of asphalt concrete mixtures are:
 - A. binder content, flexibility, stability, and rolling
 - B. stockpile analysis, hardness, stability, and durability
 - C. specific gravity, stability, durability, and flexibility
 - D. stability, flexibility, durability, and resistance to skidding

8. Type IM-19.0A asphalt concrete is:
 - A. a base course mix
 - B. a surface course mix
 - C. an intermediate course mix
 - D. a cold mix

9. The resistance an asphalt concrete pavement has to the passage of air and water into or through the pavement is known as:
 - A. penetration
 - B. flexibility
 - C. impermeability
 - D. skid resistance

10. Type BM-25.0 asphalt concrete is a:
 - A. base course mix
 - B. surface course mix
 - C. binder course mix
 - D. cold mix

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Study Questions (continued)

11. The upper or top layer of an asphalt concrete pavement structure is the:
 - A. base course
 - B. surface course
 - C. binder course

12. The subgrade ultimately carries all traffic loads.
 - A. True
 - B. False

13. The main structural strength element of a pavement is the:
 - A. subgrade
 - B. base course
 - C. surface course

14. The layer of an asphalt concrete pavement that distributes traffic loads to the subgrade is the :
 - A. surface course
 - B. intermediate course
 - C. base course
 - D. drainage layer

15. Stability may be improved by using aggregates with rough surface texture.
 - A. True
 - B. False

