6-03.1 GENERAL. Pavements are designed to provide adequate support for loads imposed by traffic, and to provide a uniformly firm, stable, smooth, all-weather surface. To achieve these objectives, the subgrade, base, and surface are designed so that the pavement will not fail under design loads. Pavements are either flexible (asphalt) or rigid (concrete) and are divided into three categories: Heavy Duty, Medium Duty and Light Duty. The category of pavement duty for each route is indicated in Figure 6-03.13, which describes various pavement corridors. The figure is based on projected accumulative ESALs over a 35 year period for each route and is kept current by the Transportation Planning Division. When necessary, the Construction and Materials Division may use criteria other than that stated in this manual in order to arrive at a design that is appropriate for special circumstances that occur.

6-03.2 DEFINITIONS.

6-03.2 (1) ESALs. ESALs are defined as the summation of equivalent 18,000 lb [8,165 kg] single axle loads (ESAL) for the design period. For purposes of pavement thickness determination, the number of ESALs used is adjusted to represent the lane with the heaviest use. Rigid ESALs and flexible ESALs will not be the same for a given section of pavement and both numbers must be determined prior to pavement design. If cumulative ESALs are provided for a given roadway by the Transportation Planning Division, it should be noted whether they are for bi-directional or uni-directional traffic. Bi-directional ESALs need to be divided in half before using the pavement thickness tables in Figures 6-03.11 and 6-03.12. All projects shall use 35-year ESALs, except short bridge projects, which shall use 20-year ESALs.

6-03.2 (2) HEAVY DUTY PAVEMENTS. Heavy duty pavements consist of all interstate and select primary routes with more than 50 million accumulative flexible or rigid ESALs for a 35 year period. See Figure 4-04.1 for the typical sections and geometric details, and Figures 6-03.8, 6-03.9 and 6-03.10 for pavement and shoulder details.

6-03.2 (3) MEDIUM DUTY PAVEMENTS. Medium duty pavements consist of all routes with either 25-50 million accumulative flexible ESALS or 40-50 million accumulative rigid ESALs for a 35 year period. See Figure 4-04.1 for the typical sections and geometric details, and Figures 6-03.6, 6-03.7, 6-03.9, and 6-03.10 for pavement and shoulder details.

6-03.2 (4) LIGHT DUTY PAVEMENTS. Light duty pavements consist of all routes not included in the heavy or medium duty pavement categories. Light duty pavements are further divided into four categories by ADT (Average Daily Traffic). See Figure 4-04.1 for the typical sections and geometric details, and Figures 6-03.1, 6-03.2, 6-03.3, 6-03.4 and 6-03.5 for pavement and shoulder details.

6-03.2 (5) PAVEMENTS FOR TEMPORARY AND LOCAL ROADS. If the number of design ESALs is between zero and 75,000 and if dust can be tolerated, a 2 in. [50 mm] thickness of gravel, crushed stone, or chat can be used. The primary applications of an aggregate surface are (1) temporary bypasses, (2) outer roadways, and (3) roadways to be turned over to another agency. When a dust free surface is required, a rigid or flexible design is determined using Figures 6-03.11 or 6-03.12.

6-03.2 (6) LIFE CYCLE COST ADJUSTMENT. For alternate pavements as defined in Subsection 6-03.4, a life cycle cost adjustment factor will be added to the lowest asphalt bid to take into consideration the future rehabilitation cost for each pavement type. This life cycle cost adjustment factor considers future cold milling and overlay of the surface layer of asphalt at 20- and 33-year intervals and diamond grinding of the concrete surface at 25 years. The last published real interest rates from the United States Office of Management and Budget will be used to bring the future costs to present worth. The Design Division will calculate the cost adjustment factor utilizing the most updated information available. Projects that contain an aggregate total of more than 2 lane-miles of paving bid as alternate pavements will include the life cycle cost adjustment factor as calculated by the Design Division. Projects with less than 2 lane-miles bid as alternate pavements will have a $0 life cycle cost adjustment factor.

6-03.2 (7) LANE-MILE. A lane-mile is defined as pavement 12 ± 2 feet (3.6 ± 0.6 m) wide and 1 mile (1.6 km) in length. Full depth paved shoulder widths that have the same pavement type as the mainline should be proportionally (compared to 12 ft. [3.6 m] width) included when calculating lane lane-miles.

6-03.3 PAVEMENT THICKNESS DETERMINATION. The Construction and Materials Division will make the pavement thickness determination for all projects. A pavement thickness request should be submitted to the Pavement Section in the Construction and Materials Division, with a copy to the Design Division during preliminary design. The request should include the following information:

- a description of the existing and proposed design template for the mainline, ramps and any other roadways associated with the project (appurtenances) requiring a pavement structural design
- the existing pavement structure on each end of the new pavement
- special conditions prevalent within the project area that may affect design consideration
- location sketch and length of each new pavement to be designed, including log mile [log km] reference and exceptions
- date the pavement thickness determination is needed to maintain the project development schedule
- traffic data (construction year ADT, design year ADT, flexible and rigid ESAL's)
- soils survey

The district should request a review of the study if the project changes, such as (1) being delayed beyond the anticipated construction year, (2) traffic loads change, (3) being expanded or broken into sections, or (4) a revised typical section or other standards revisions, etc.

6-03.4 ALTERNATE PAVEMENTS. To ensure that every effort is being made to increase the competition for paving contracts, and that the latest market rate is considered when determining pavement type, contractors should be allowed to bid an alternate pavement design. Future maintenance costs will be considered with a life cycle cost adjustment factor, thus resulting in the most equivalent specifications possible to draw in the maximum number of bidders for MoDOT paving projects. While alternate bidding is generally advantageous for all projects, circumstances occasionally arise which cause one pavement type to be preferred over the other.

For projects less than 2 lane miles, alternate bidding is not required, but the core team should look at alternate pavement options that bring the best value to the project. Consideration should be given to initial construction cost, long-term maintenance cost, and continuity with existing pavement. Also, impacts to local residents and business along the route should be considered.

Pavements having prevailing issues that make only one type of pavement desirable should be examined to determine the feasibility of alternate bids on pavement. These may include circumstances such as widening existing pavements with safety and durability issues due to differing pavement types in the driving lanes, urban construction, consideration of how the pavement type effects the major item of work for the project (e.g., if major item of work for the project is bridge work the life cycle costs may be insignificant to the total project cost), total amount of paving compared to existing pavement, project staging and project scoping with regard to long-range transportation goals.

If there is a need to specify one pavement type over another on any project, the core team is responsible for making the decision. The Project Manager is responsible for documenting the reasons for the decision in the Project Scoping Memorandum (See Subsection 1-02.7).

6-03.4 (1) PLANS FOR PROJECTS WITH ALTERNATE PAVEMENTS. Plans for all projects with alternate pavements should contain:

- Typical sections for both alternates, including station limits, and all side road connections.
- All pay items for full depth alternate pavements shall be in square yards for the entire pavement surface.
- One set of 2B sheets with separate sheets for the items associated with each alternate.

- Using the "Estimate 2000" program, the quantities for pavement and other items associated only with the asphalt alternate (designated as "Alternate A") should be designated as "Section 02" and the quantities for pavement and other items associated only with the concrete alternate (designated as "Alternate B") should be designated "Section 03". This will enable summation of the appropriate subtotals to compile an estimated total cost per alternate.
- No pay item listed in Section 02 or 03 should be listed in Section 01. This would lead to differing bids and cause confusion when administering the contract. For example, if the base quantities differ, include the appropriate total base quantities in Sections 02 and 03, but not Section 01.
- For shoulder rumble strips, include the bituminous rumble strip pay item with the asphalt alternate, and the concrete rumble strip pay item with the concrete alternate.
- Design Special Provision-ALTERNATE FOR PAVEMENTS DSP-96-04 should be inserted in the Job Special Provisions. The Life Cycle Cost adjustment factor is calculated by the Central Office.
- Aggregate total lane-miles of paving (See Subsection 6-03.2(7)).

Following are design guidelines for different project scenarios:

6-03.4 (2) SEPARATE GRADING AND PAVING PROJECTS WITH 18 IN. ROCK BASE.

- Subgrade profile and cross sections should be designed for the **thicker** pavement alternate.
- If the thinner option is constructed, the contractor will be responsible for maintaining the profile grade. In the paving project the addition of subgrade material for the thinner pavement design will be paid for as Subgrading and Shouldering, Class 2.

6-03.4 (3) SEPARATE GRADING AND PAVING PROJECTS WITHOUT 18 IN. ROCK BASE.

- Subgrade, profile and cross sections should be designed for the **thinner** pavement alternate.
- If the thicker option is constructed the contractor will be responsible for maintaining the profile grade. In the paving project the removal of subgrade material for the thicker pavement design will be paid for as Subgrading and Shouldering, Class 1.
- Crossroad structures should be designed to accommodate a minimum cover based on the thicker pavement design.

6-03.4 (4) COMBINED GRADING AND PAVING PROJECT.

- Subgrade profile and cross sections should be designed for the **thinner** pavement alternate.
- The contractor will be responsible for maintaining the profile grade for either alternate pavement with no direct pay.
- Crossroad structures should be designed to accommodate a minimum cover based on the thicker pavement design.

6-03.5 FLEXIBLE PAVEMENT DESIGN.

6-03.5 (1) THICKNESS DESIGN. The design table shown on Figure 6-03.11 is used as a basis for determining flexible pavement thickness. When contractor furnished borrow is to be provided, the contract should state that it shall meet or exceed the group index assumed during the pavement type selection process. A job special provision may be used with the minimum soil characteristics. Although final decisions regarding pavement thickness are made by the Construction and Materials Division, the districts are at liberty to employ the use of this flexible pavement design table in order to make specific recommendations regarding the principal roadway, outer roadway, service road, or temporary bypass pavement thickness.

6-03.5 (2) BITUMINOUS MIXTURES AND ASPHALT BINDERS. Refer to Section 6-07 for guidelines on selection of bituminous mixtures and asphalt binders to be used in full depth pavements.

The mix quality is specified for all layers. The lift thickness of the surface mixture is specified as $1^{3}/_{4}$ in. [45 mm]. The lift thickness may be specified in some cases for the first underlying layer. It is not necessary to specify lift thicknesses for the remaining underlying layers. Computation of the square yard [m^2] quantities for all bituminous mixtures for full depth pavements should be based on the final surface area of the pavement. No allowance should be made for the construction of the required 1:1 slope along the edge of the pavement or an individual lift. When payment is made by the ton [Mg], the material in the required 1:1 slope is included in the volumetric calculation.

Where a different type of mixture is specified for the shoulder than the traveled way, the type of material should be changed at the shoulder construction joint as specified on the plans.

6-03.6 RIGID PAVEMENT DESIGN.

6-03.6 (1) THICKNESS DESIGN. The design table shown in Figure 6-03.12 is used as a basis for determining rigid pavement thickness. Although final decisions regarding pavement thickness are made by the Construction and Material Division, the districts may use this rigid pavement design table in order to make specific recommendations regarding the principal roadway, outer roadway, service road, or temporary bypass pavement thickness.

6-03.6 (2) REINFORCEMENT. The rigid design table assumes that the concrete will be non-reinforced and will have tied concrete shoulders. All roadway transverse joints are doweled. Tied rigid shoulders should not be doweled unless they are intended to be used as a future driving lane. All longitudinal joints are connected with deformed tie bars. Special consideration for reinforcement may be necessary when new lanes are added adjacent to existing lanes.

6-03.6 (3) JOINTS. Contraction joint spacings are shown on the standard plans. For light duty pavements with greater than 1700 ADT and all medium and heavy duty pavements, the longitudinal joint adjacent to or within the shoulder on the outside lane will be located 2 ft. [0.6 m] from the edge of the outside travel lane, except when the shoulder is expected to be used as a future lane in which case the joint is located at the edge of the outside lane. Minor arterial streets and urban sections are shown in Figures 4-07.2, 4-07.3 and 4-07.4. Longitudinal joints are located in such manner that the joint will tend to guide traffic. Details for pavement joints and the location of joints for typical pavements, including typical intersections, are shown on the standard plans. The design plans include details for pavement joint layouts of typical sections and intersections not covered on the standard plans.

6-03.7 COMPOSITE PAVEMENT DESIGN. This is the least desireable pavement type but occasionally, the Construction and Materials Division will furnish the district a composite pavement design consisting of an asphaltic concrete surface on a portland cement concrete base.

6-03.8 BASE CONSIDERATIONS. Bases are provided for several reasons, including to provide drainage, to reduce or eliminate pumping (ejection of fine-grained soil and water from beneath the pavement), to provide a working platform for overlying pavement placement, for improvement of subbase characteristics, or as a separator layer.

- All heavy duty pavements are placed on an 18 in. [0.45 m] rock base or a permeable base over Type 1 base.
- All medium duty pavements are placed on an 18 in. [0.45 m] rock base or a Type 5 aggregate base.
- All light-duty pavements are placed on an 18 in. [0.45 m] rock base or a Type 1 aggregate base.
- The Construction and Materials Division will indicate when a modified subgrade is necessary along with the thickness determination.

The Construction and Materials Division will provide a recommendation for base type with the pavement thickness determination.

6-03.8 (1) STABILIZED PERMEABLE BASE. Stabilized permeable base, sometimes referred to as open graded treated base, provides rapid positive drainage. The components are coarse-graded crushed stone with virtually no fines stabilized with asphalt cement or Portland cement. The layer thickness is typically 4 in. [100 mm]. Type 1 aggregate base is used as a separator layer under stabilized permeable base to prevent infiltration of fines.

6-03.8 (2) ROCK BASE. The preferred base for all new rigid and flexible pavements, light, medium or heavy duty, is an 18 in. [0.45 m] rock base whenever available in suitable quantities on or in close proximity to the job. Rock base consists of 18 in. [0.45 m] of Class C excavation. It is placed full roadbed width and daylighted to the in-slope or fill-slope, except on the high side of superelevated curves and when not economically feasible under light duty pavements. In this case the rock base is not daylighted to the ditch and soil is used as a fill material. Undergrading in rock cuts is performed to allow placement of the full specified lift thickness. A 4 ft. [1.2 m] deep ditch is preferred. Determination of rock base availability must be made early in the project through consultation with the District Geologist and materials personnel, as elevations, pavement structure design and other considerations may be affected when used.

6-03.8 (3) TYPE 5 AGGREGATE BASE. Type 5 base is used to provide moderate drainage, reduce or eliminate pumping and provide a working platform. Drainage capability is much lower than permeable base, but still enough to keep water from contacting the pavement bottom when properly sloped. Typical thickness is 4 in. [100 mm]. Where Type 5 base is used, it extends a distance from the pavement edge as shown in Figures 6-03.6, 6-03.7, 6-03.8, and 6-03.10, or 18 in. [460 mm] from the back of curbs or curb and gutter sections.

6-03.8 (4) TYPE 1 AGGREGATE BASE. Type 1 aggregate base is used to provide a working platform or a separator layer between pavement or permeable base and the soil subgrade. It is a more stable material with higher fines content. Typical thickness is 4 in. [100 mm]. Where Type 1 base is used, it extends a distance from the pavement edge as shown in Figures 6-03.1, 6-03.2, 6-03.3 and 6-03.4.

6-03.8 (5) MODIFIED SUBGRADE. Subgrade soils are modified with lime, flyash, lime kiln dust, or other material to decrease the plasticity index (PI) and increase stiffness. The dosage rates of modifying material vary depending on the soil type to provide a working platform and/or pavement structure, but generally no drainage. Typical minimum thickness is 6 in. [150 mm], but may range up to 12 in. [300 mm] or greater. District or Central Office Soils and Geology personnel may identify the need for this item during design; however, the need for modified subgrade is usually determined during construction operations.

6-03.9 RAMP AND HIGH SPEED DIRECTIONAL RAMP DESIGN. See Typical Section D-53 for multi-lane ramps, D-50 for diamond/directional (single lane) ramps, and D-51 for loop ramps.

6-03.10 MEDIAN OPENINGS AND AUXILIARY LANES. Median openings and auxiliary lanes are designed with the same thickness as the mainline pavement.

6-03.11 TEMPORARY BYPASS. A temporary bypass should normally be designed as a flexible pavement, including those used on interstates. If the bypass is to be in place for only one construction season, the pavement structure should consist of a plant mix bituminous base (PMBB) mixture. The thickness should be determined using the design table shown on Figure 6-03.11, based on the projected total flexible ESALs for a two-year period and the appropriate soil group index of the subgrade at the bypass location. The PMBB material should be placed directly on the subgrade, with the subgrade being compacted in accordance with Sec 203.4 of the standard specifications.

If the bypass is to be used for more than one construction season, i.e., in place over winter months, the thickness of the pavement structure should be determined as above, except the ESALs should be double the amount accumulated while the bypass is to be in use. The top lift of the pavement structure should consist of a $1^3/_4$ in. [45 mm] plant mix bituminous pavement (PMBP), with the remainder design thickness consisting of a PMBB mixture. The PMBB should be placed on a 4 in. [100 mm] Type 1 or 5 aggregate base over a subgrade compacted in accordance to Sec 203.4 of the standard specifications. If the bypass is to be left in place for more than three years, consideration should be given to Superpave mixtures or concrete in lieu of the plant mix bituminous mixtures.

In cases where the bypass pavement can be incorporated into a permanent roadway pavement, the bypass should be designed to the same thickness and type as the proposed pavement.

If the number of design ESALs is between zero and 75,000 and if dust can be tolerated, a 2 in. [50 mm] thickness of gravel, crushed stone, or chat may be used for the temporary bypass. When a dust free surface is required, a flexible design is determined as described above.