# Chapter 3. Pavement Design – County Street Construction

## 3.01 Introduction

All engineering drawings proposing construction of public streets shall be required to provide a pavement design. The design shall be prepared and sealed by a Maryland licensed Professional Engineer specializing in geotechnical or pavement engineering.

## 3.02 Development of Traffic

A first step in the design process is determination of traffic. The following assumptions may be made for average annual daily traffic (AADT) counts on residential streets:

- Residential local access (local) – 250
- Residential subcollector – 2,500
- Residential collector (60 ft right-of-way) – 4,000

For streets classified as other than residential collector, a detailed traffic analysis shall be required projecting traffic on the new roadway or detailed traffic counts shall be required for reconstruction of existing roadways including percentages of vehicles by type. Assumed percentages of vehicles by type for residential streets are as shown in Table 1.

**Table 1. Percentage of vehicles by classification**

| Vehicle | Percentage of vehicles by type | | |
|---|---|---|---|
| | Residential Local Access | Residential Subcollector | Residential Collector |
| Cars | 96.8% | 93.0% | 90.0% |
| Trucks, 2-axle 4-tire | 2.4% | 5.1% | 7.1% |
| Trucks, 2-axle 6-tire | 0.4% | 0.7% | 1.1% |
| Trucks, 3 axles | 0% | 0.3% | 0.4% |
| Tractor semi-trailer, 4-axles | 0% | 0.2% | 0.3% |
| Tractor semi-trailer, 5-axles | 0.4% | 0.7% | 1.1% |

Estimates of truck percentages do not include construction traffic associated with build-out of a new residential area. An estimated 80 18-kip equivalent single axle loads (ESALs) is associated with construction of each house. Therefore, the number of trucks is based on the number of lots to be serviced by each roadway.

## 3.03 Matrix Pavement Design

A matrix is provided of typical sections that may be used under certain conditions. In particular, these sections apply to construction of residential/subdivision streets. Industrial collector, commercial collector, rural collector, and arterial pavement sections shall be developed in accordance with Section 3.04 using appropriately estimated traffic levels.

The matrix shall be used for all residential/subdivision streets, any street with daily traffic up to 4,000 vehicles and 10 percent trucks, or an estimated design ESALs of up to 586,800.

### *3.03.01 Staged Construction*

In construction of new residential areas, staged construction may be necessary. The first stage incorporates construction to support traffic building new homes. The second stage involves the placement of the final surfacing after the subdivision has been substantially built out and prior to acceptance by the County. The matrix provides typical sections that may be used in either staged or nonstaged construction. When staged construction is used, the surface layer shall be placed after substantial build-out of the subdivision.

### *3.03.02 Investigation Requirements*

A geotechnical report will be required sealed by a Professional Engineer. As a minimum, the report shall include the following items:

- Plans showing boring and sampling locations. Bores shall be obtained after mass grading at a maximum spacing of 500 ft with a minimum of three borings for a roadway.
- Road layout.
- Suitability of all proposed road subgrade materials.
- Classification of the subgrade including both the Unified Soil Classification designation and the American Association of State Highway and Transportation Officials (AASHTO) designation.
- Laboratory test results that demonstrate the California Bearing Ratio (CBR). Any CBR below a value of 2 will require mitigation for the low value. These areas will be undercut and backfilled with suitable material. The report will identify the locations where this measure is required.
- The various recommended pavement sections for each proposed road provided as typical cross section details.

### *3.03.03 Details of Section Development*

The pavement sections within the matrix were developed in accordance with the 1993 AASHTO Guide for the Design of Pavement Structures. Table 2 presents the parameters used in the development of the designs presented in the matrix.

**Table 2. Parameters used in matrix pavement section development**

| Parameter | Value | |
|---|---|---|
| | Residential Local Access | All Others |
| Reliability | 80% | 90% |
| Standard Deviation | 0.45 | 0.45 |
| Initial Serviceability | 4.2 | 4.2 |
| Terminal Serviceability | 2.4 | 2.6 |

Table 3 presents the development of the 18-kip equivalent single axle load counts for use in developing the matrix pavement sections. In each case, a growth rate of 2.2%/year is assumed. The directional distribution is set to 50% and the lane distribution for one lane in each direction of travel is 100% and for two lanes in each direction of travel is 90%. The design life is set at 20 years.

Table 4 presents the matrix of sections to be used for construction of residential pavements. The matrix presents a minimum pavement section to be used for all cul-de-sac pavements.

**Table 3. Development of design ESAL estimates**

| Vehicle | AADT | Design Traffic | ESAL Factor | Design ESAL |
|---|---|---|---|---|
| **Residential Local Access** | | | | |
| Cars | 242 | 2,189,453 | 0.0008 | 1,752 |
| Trucks, 2-axle 4-tire | 6 | 54,284 | 0.01 | 543 |
| Trucks, 2-axle 6-tire | 1 | 9,048 | 0.3 | 2,715 |
| Trucks, 3-axle | 0 | 0 | 0.78 | - |
| Tractor semi-trailer, 4-axle | 0 | 0 | 1.44 | - |
| Tractor semi-trailer, 5-axle | 1 | 9,048 | 1.44 | 13,030 |
| All Vehicles | 250 | | | 18,040 |
| By Direction, Single Lane | | | | 9,020 |
| | | | | |
| **Residential Subcollector** | | | | |
| Cars | 2,325 | 21,035,030 | 0.0008 | 16,829 |
| Trucks, 2-axle 4-tire | 127 | 1,149,011 | 0.01 | 11,491 |
| Trucks, 2-axle 6-tire | 18 | 162,852 | 0.3 | 48,856 |
| Trucks, 3-axle | 7 | 63,332 | 0.78 | 49,399 |
| Tractor semi-trailer, 4-axle | 5 | 45,237 | 1.44 | 65,142 |
| Tractor semi-trailer, 5-axle | 18 | 162,852 | 1.44 | 234,507 |
| All Vehicles | 2,500 | | | 426,224 |
| By Direction, Single Lane | | | | 213,112 |
| By Direction, 2-Lane | | | | 191,801 |
| | | | | |
| **Residential Collector** | | | | |
| Cars | 3,600 | 32,570,369 | 0.0008 | 26,057 |
| Trucks, 2-axle 4-tire | 284 | 2,569,441 | 0.01 | 25,695 |
| Trucks, 2-axle 6-tire | 44 | 398,083 | 0.3 | 119,425 |
| Trucks, 3-axle | 16 | 144,758 | 0.78 | 112,912 |
| Tractor semi-trailer, 4-axle | 12 | 108,568 | 1.44 | 156,338 |
| Tractor semi-trailer, 5-axle | 44 | 398,083 | 1.44 | 573,240 |
| All Vehicles | 4,000 | | | 1,013,667 |
| By Direction, Single Lane | | | | 506,834 |
| By Direction, 2-Lane | | | | 456,151 |

**Table 4. Matrix of Pavement Sections**

| Road Classification / Project ESAL[1] per Lane | CBR[2] | Resilient Modulus ($M_R$), psi[3] | Pavement Section | | | | Calculated ESALs[7] |
|---|---|---|---|---|---|---|---|
| | | | GAB, in[4] | HMA Base, in[5] | HMA Surface, in[5,6] | Total Thickness, in | |
| Cul-de-sac | Min 2 | Min 4,000 | 6 | 4.0 | 1.5 | 11.5 | 27,800 |
| Residential Local Access<br><br>9,000 ESALs | 2 | 4,000 | 6 | 4.0 | 1.5 | 11.5 | 116,700 |
| | 3 | 5,200 | 6 | 4.0 | 1.5 | 11.5 | 213,000 |
| | 5 | 7,200 | 6 | 4.0 | 1.5 | 11.5 | 454,800 |
| | 8 | 9,700 | 6 | 4.0 | 1.5 | 11.5 | 913,900 |
| Residential Subcollector (1 or 2 lanes in each direction)<br><br>237,100 ESALs[8] | 2 | 4,000 | 8 | 4.5 | 2.0 | 14.5 | 248,700 |
| | 3 | 5,200 | 7 | 4.0 | 2.0 | 13.5 | 259,400 |
| | 5 | 7,200 | 6 | 4.0 | 2.0 | 12.0 | 454,700 |
| | 8 | 9,700 | 6 | 4.0 | 2.0 | 12.0 | 913,600 |
| Residential Collector (1 or 2 lanes in each direction)<br><br>586,800 ESALs[9] | 2 | 4,000 | 8 | 6.0 | 2.0 | 16.0 | 685,600 |
| | 3 | 5,200 | 8 | 5.0 | 2.0 | 15.0 | 645,200 |
| | 5 | 7,200 | 8 | 4.0 | 2.0 | 14.0 | 670,700 |
| | 8 | 9,700 | 6 | 4.0 | 2.0 | 12.0 | 913,600 |

[1]ESAL = 18-kip equivalent single axle load
[2]CBR = California Bearing Ratio
[3]$M_R = 2555 \times CBR^{0.64}$
[4]GAB = Graded Aggregate Base
[5]For specific mix designations for HMA base and surface layers, see Section 3.05.01
[6]HMA surface is assumed to occur after significant build-out of the subdivision has been completed.
[7]Allowable ESALs estimated based on pavement section identified. Calculation of allowable ESALs based on final construction.
[8]Assume residential subcollectors service a maximum of 300 homes. The matrix pavement section shall not be used if this condition is exceeded and a non-matrix pavement design report shall be required.
[9]Assume residential collectors service a maximum of 1,000 homes. The matrix pavement section shall not be used if this condition is exceeded and a non-matrix pavement design report shall be required.

## 3.04 Non-Matrix Pavement Design

The matrix may not be used when the California Bearing Ratio (CBR) of the subgrade is less than 2 or when the road is classified higher than residential collector.

### *3.04.01 Design Requirements*

A detailed pavement design must meet the following criteria:

- Performed in accordance with the 1993 AASHTO Guide for the Design of Pavement Structures. Other methodologies may be used only if approved by the Frederick County Division of Public Works.

- Bores should be obtained at a maximum spacing of 500 ft with a minimum of three borings for a roadway. At each location, the subgrade classification should be determined in accordance with both the Unified Soil Classification designation and the American Association of State Highway and Transportation Officials (AASHTO) designation. Additionally, the CBR shall be determined at each location.

- Reliability (R) shall be 80% for residential local access roads and 90% for all other functional classes.

- The standard deviation (S) shall be 0.45.

- The design life of the pavement section shall be 20 years.

- Traffic volume and classification counts shall be based on the minimum counts provided in Section 3.02 or shall be based on counts of nearby roadways of similar classification and use. Traffic counts shall be required on roadways with classifications higher than residential collector.

- The 18-kip ESAL estimate shall be estimated using the following factors:
  - Growth Rate: 2.2% per year
  - Directional Distribution: 50%
  - Lane Distribution for single lane of travel in each direction: 100%
  - Lane Distribution for two lanes of travel in each direction: 90%
  - Truck Factors will be:
    - Cars – 0.0008
    - Trucks, 2-axle 4-tire – 0.01
    - Trucks, 2-axle, 6-tire – 0.3
    - Trucks, 3-axle – 0.78
    - Tractor Semi-trailer, 4-axle – 1.44
    - Tractor Semi-trailer, 5-axle – 1.44

- Initial Serviceability: 4.2

- Terminal Serviceability:
  - For residential local access – 2.4
  - All other road classifications – 2.6

- Structural Coefficients (per MDSHA Pavement and Geotechnical Design Guide, maximum layer thicknesses are as shown in Section 3.05)
    - HMA Surface – 0.44
    - HMA Base – 0.40
    - Cement Treated Base – 0.25
    - Asphalt Treated Aggregate Base – 0.20
    - Graded Aggregate Base – 0.10

### *3.04.02 Submission Requirement*

A design report shall be submitted sealed by a Professional Engineer. The report shall provide the following documentation:

- Introduction and proposed scope;
- Method of subsurface exploration;
- Laboratory testing: grain size, index property, proctor testing, CBR;
- Discussion of pavement subgrade material;
- Method of design and design assumptions;
- Recommended pavement section(s);
- Discussion of subgrade stabilization, as needed;
- Drainage recommendations;
- If staged construction is planned, documentation regarding design to meet construction traffic prior to placement of final surfacing; and
- Plans showing boring location and street layout.

## 3.05 Notes on Construction

### *3.05.01 Asphalt Mixes*

Binders for asphalt surface mixes shall be selected in accordance with Table 5. All other mixes shall use a PG64-22 binder.

**Table 5. Binder Types for Surface Mixes**
**(per MDSHA Pavement and Geotechnical Design Guide)**

| Traffic Speed | Traffic (ESALs) | | |
|---|---|---|---|
| | < 300,000 | 300,000 to 3 Million | > 3 Million |
| ≥ 45 mph | PG64S-22 | PG64S-22 | PG64E-22 |
| 15 to 45 mph | PG64S-22 | PG64S-22 | PG64E-22 |
| < 15 mph | PG64S-22 | PG64E-22 | PG64E-22 |

Compaction levels for mix designs shall be as follows:

- Level 1: Design ESALs < 0.3 Million
- Level 2: 0.3 Million ≤ Design ESALs < 6.5 Million
- Level 4: Design ESALs ≥ 6.5 Million

Lift thicknesses, maximum layer thicknesses, and uses for the various mix sizes shall be selected in accordance with Table 6. The Preferred column in Table 6 is provided as guidance in developing the pavement design. In order to meet the required thickness for the pavement section, use of lift thicknesses anywhere within the range shown in Table 6 is appropriate.

**Table 6. Aggregate Size and Lift Thickness**
**(per MDSHA Pavement and Geotechnical Design Guide)**

| Lift Thickness, inches | | | Layer Total Maximum | Mix Size | Design Application |
|---|---|---|---|---|---|
| Minimum | Preferred | Maximum | | | |
| 3.0 | 4.0 | 5.0 | 10.5 | 25.0 mm | Base, Patching |
| 2.0 | 3.0 | 4.0 | 9.0 | 19.0 mm | Base, Patching |
| 1.5 | 2.0 | 3.0 | 6.0 | 12.5 mm | Non-Residential Area Surface, Binder |
| 1.0 | 1.5 | 2.0 | 3.0 | 9.5 mm | Surface, Leveling |

A tack coat shall be applied per MDSHA Specification Section 504.03.

When staged construction is to be implemented, a minimum thickness of either 4 inches of HMA base or 1.5 inches of HMA binder on 2.5 inches of HMA base shall be placed for Stage I use. Either of these structures shall be placed on the appropriate thickness of GAB per the pavement design.

Prior to placement of the surface mix (Stage II of construction):
1) Sweep the surface to remove any accumulated debris.
2) The existing pavement shall then be inspected by the County or their representative and any distresses shall be repaired.
3) If the HMA base is polished as determined by the County, the surface shall be roughened prior to application of the surface layer.
4) Apply tack coat per MDSHA Specification Section 504.03.

### *3.05.02 Aggregate Base Construction*

Maximum aggregate base thickness by material type is as follows:

Cement Treated Aggregate – 6 inches
Asphalt Treated Aggregate – 6 inches
Graded Aggregate Base – 8 inches

Aggregate base course shall be placed within 48 hours of acceptance of subgrade materials by the County Inspector unless delay is approved by County. If a precipitation event occurs during this time frame, the County Inspector shall reinspect the subgrade prior to placement of the aggregate base course.

Prime coat should be applied to aggregate base material prior to placement of any HMA.

### *3.05.03 Density Requirements*

Compact the material that is 1 ft below the top of subgrade to at least 92 percent of the maximum dry density per AASHTO T 180 Modified proctor. Compact the top 1 ft to at least 97 percent of the maximum dry density per AASHTO T 180 Modified proctor. Determine in-place density per MSMT 350 or 352. When necessary, add water or dry the layer in order to compact to the required density. When finally compacted to the required density, the resultant moisture content of embankment material shall be within two percentage points of optimum.

Compaction of graded aggregate base courses shall be to at least 97% of maximum dry density per Modified proctor (AASHTO T180 Modified proctor).

Chemically stabilized aggregate base shall be compacted to at least 95% of maximum dry density per Modified proctor (AASHTO T180 Modified proctor).

During construction the density of HMA shall be evaluated per MDSHA Specification 504.03.11. Target density of placed material should be between 92% and 97%.

### *3.05.04 Drainage Options*

Subgrade drainage is to be placed in accordance with MDSHA Standard 387.51.

Longitudinal underdrains shall be placed, as needed, in accordance with MDSHA Standard 387.11 or 387.11A, as appropriate. Specific locations shall be included on improvement plans or civil drawings.

Provide for 1-inch weeps in inlets for staged construction of curb and gutter sections.

The gutter pan should rest on top of the aggregate base material or a minimum of 4 inches of granular aggregate base where a bound base material (either HMA base or chemically stabilized aggregate base) is used.

A cross slope of up to 3% is acceptable with approval from the County. This cross slope should receive additional consideration with respect to ADA Standards for Frederick County Right-of-Way where sidewalks are planned adjacent to the roadway. The 3% cross slope may be helpful in areas where drainage may be a concern due to the existing terrain, such as where a designed road is relatively flat.