State of Oklahoma
County Highway System
Design Guidelines
Manual
2013

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Developed Jointly by
Oklahoma Department of Transportation
and the
Association of County Commissioners of Oklahoma
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PREFACE

The Oklahoma Department of Transportation, ODOT, and the Association of County Commissioners of Oklahoma, ACCO, pursuant to State Statute Title 69 § 689 first developed the County Roads Design Guidelines Manual in 1991. The intent here is to update methodologies and information for future use in the design on the County Highway System. The Design Subcommittee made recommendations and forwarded those recommendations on for comments to the Oklahoma Department of Transportation, Circuit Engineering Districts, Federal Highway Administration, and the Oklahoma Association of County Engineers.

Counties and Engineers use this manual as guidance on projects that exist on the County Highway System. These projects may be classified as:

(Examples of work activities included)
1. New Construction - new alignment
2. Reconstruction - major changes to horizontal/vertical alignment, pavement structure
3. Resurfacing, Restoration, Rehabilitation (3R) – overlays, minor pavement width and/or alignment changes.

If existing or future traffic counts surpass 2,500 Average Daily Traffic then the engineer shall refer to the appropriate ODOT and/or AASHTO guidelines.


Herein are minimum acceptable design criteria that the designer should make every effort to surpass while considering social, economic and environmental impacts.

The presentation of new design values in this text does not imply that the existing county roads are unsafe, nor does it mandate the initiation of improvement projects. For 3R projects existing design values/geometrics may be retained. Specific site investigations and accident history analysis often indicate that the existing design features are performing in satisfactory manner. The cost of full reconstruction for these facilities will often not be justified.

These guidelines do not include information on ADA compliance or storm water management. The Engineer and Owner should ensure that current state and federal laws are observed. Use of sound engineering judgment prevails over manual guidelines. The guidelines’ purpose is to provide a safe, cost-effective road system.
The subcommittee has made every effort to balance safety, costs and engineering judgment in the development of these guidelines.

Design Subcommittee:
Shannon Sheffert, P.E., Local Government Division Engineer, ODOT
Rosemarie Case, P.E., Local Government Engineer, ODOT
Jim DeCastro, P.E., Circuit Engineering District 4 Engineer
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Bradley Manhalter, P.E., Oklahoma Turnpike Authority
James Stevenson, P.E., Area Engineer, FHWA
Randall Leonard, P.E., Structural Engineer, FHWA
Randy Robinson, P.E., Transportation Engineer, OCCEDB
Chris Schroder, Administrative Assistant, OCCEDB
A. GENERAL INFORMATION

In order that all submitted plans be compatible and consistent with ACCO and ODOT policies the plans should be developed using ODOT guidelines.

1. Seed files for typical roadway plans can be obtained from ODOT Local Government or by going to ODOT’s website at www.odot.org/roadway. The files can be found under CADD V8i seed files.

2. The latest version of Pay Items and Roadway Standards and Pay Item Notes can also be found on the same Roadway page.

3. ODOT Standard Drawings can be found at http://www.odot.org/cnstrctengr.htm on ODOT’s web page. Traffic Pay Item Notes can be found with the Traffic Standard Drawings.

Please note that on Pay Item Sheets, the pay item descriptions must exactly match the pay items listed on ODOT’s master Pay Item list, http://www.okladot.state.ok.us/contracts/itemlist.htm
Index of Sheets

The following is a typical order of sheets. Dependent on the project, more or fewer sheets may be required.

1. Cover
2. Typical
   a. Roadway Typical
   b. Guardrail Widening Typical
   c. Drive Typical
3. Summary of Pay Quantities & Notes (Roadway)
4. Summary of Pay Quantities & Notes (Bridge)
5. Roadway Summaries
   Use Every Time (If Applicable)
   a. Erosion Control
   b. Surfacing
   c. Earthwork
   d. Drives
   e. Drainage Structures
   f. Fence
   g. Guardrail
   h. Ditch Treatment
   i. Pavement Markings
   j. Mailbox
   k. Removals
6. Drainage Area Map
7. SWMP, Storm Water Management Plan
8. Survey Data Sheets / Alignment Data Sheets
9. Roadway Detail Sheets
   a. Roadway Details Sheet
      i. Superelevation Detail
      ii. Rounding Detail
      iii. Curb & Gutter Detail
      iv. Mailbox Turnout Detail
      v. Interface Detail (Asphalt Only)
   b. Intersection Detail
   c. Demolition Plan
10. Plan & Profile Sheets
11. Traffic Detail Sheets
    a. Signing & Striping
    b. Detour
    c. Construction Sequencing
12. Erosion Control
13. General Plan & Elevation
14. Substructure Layout
    a. Staking Diagram
15. Foundation Boring Logs
16. Details of Abutment
    a. Abutment Details
    b. Bearing Assembly
17. Details of Piers
    a. Special Design
18. Details of Superstructure
    a. Special Design
19. Details of Approach Slabs
20. Cross Sections
CHAPTER 2
SURVEY

A. GENERAL INFORMATION

These Specifications are written for utilizing the English system (U.S. Survey Foot) of measurement. These Specifications are to be used in conjunction with the “SPECIFICATIONS FOR SURVEYS FOR PRIMARY AND SECONDARY HIGHWAYS” with the following general modifications. Except where modified below or by Special Provisions, the above referenced Specifications will prevail.

All aspects of surveys performed under these specifications are to be done in a professional manner under the direct, responsible charge of a Licensed Professional Land Surveyor with current Oklahoma registration. All surveys shall meet or exceed the Oklahoma Minimum Standards for the Practice of Land Surveying as adopted by the Oklahoma State Board of Licensure for Professional Engineers and Land Surveyors, September 17, 1993, and all subsequent revisions thereto.

The unit of measurement for county surveys will be the U.S. Survey Foot.

NOTICE: Prior to entering onto any private property, the Surveyor/Consultant shall send an official notification to the landowners.

Survey notebooks will not be a required submittal on county surveys in order to allow for maximum productive utilization of total stations, GPS, digital levels, and field data recorders.

B. SURVEY LIMITS

The minimum limits of survey shall be 800 feet in each direction of the existing bridge, or shall extend beyond the limits of the flood plain; whichever is greater, or as established in the scope of work.

C. ALIGNMENT

The alignment shall be made on the section line, where feasible. If the alignment is not on a section line, complete and accurate ties are to be shown at all crossings of major land lines (angle and distance from Centerline of Survey to the land corners).

If a CL Survey exists, then all major curve points (P.C., P.I. and P.T.) are to be referenced. Complete curve data is to be shown as:
Example:  
P.I. Sta. 104+87.99  
\[X=\]
\[Y=\]
\[\Delta = \text{ (degrees, minutes, seconds)}\]
\[D = \text{ (degrees, minutes, seconds)}\]
\[T = \text{ (feet)}\]
\[L = \text{ (feet)}\]
\[R = \text{ (feet)}\]
\[E = \text{ (feet)}\]
\[V = \text{ (mph)}\]
\[S = \%\]

If an existing CL Survey does not exist, then a CL Survey shall be established and the tangents and PIs properly annotated and referenced. For a roadway project the CL Survey should be pinned every 1,000 ft. Oklahoman Registered Licensed Surveyors should use their professional judgment.

D. STATIONING

Sta.100+00.00 shall be assumed on a Section Corner or 1/4 Section Corner nearest to the BOP and stationing will decrease west & south and increase east & north from that point to meet ODOT, Survey Division specifications for stationing, except in areas where existing project stationing could be used. If using existing project stationing, show a station equation at a specific point.

E. TOPOGRAPHIC/PLANIOMETRIC DATA & SURFACE FEATURES/DIGITAL TERRAIN MODEL

The CONSULTANT/SURVEYOR will be responsible for obtaining all Topographic/Planimetric data and Surface Features/DTM data to a minimum bandwidth as follows (assuming 1600 feet survey limits): *

- 100 feet right and left of Centerline of Survey beginning and ending 600 feet in each direction of the bridge.
- Creek banks and channel shall be located to a minimum of 250 feet upstream and downstream.
- Ground shots will be taken at a maximum of 50 feet intervals and at all break points.

*This does not apply to drainage profiles, road profiles and railroad profiles, which will be in accordance with the above referenced Specifications.
F. HORIZONTAL CONTROL

Horizontal control shall be obtained by using NGS Oklahoma State Plane Coordinate System, NAD 83 (1993), (specify) Zone.

NOTE: Arbitrary Coordinate System shall not be used.

G. BEARINGS

Bearings shall be taken from (listed from most desirable to least desirable):
- NGS/ODOT H.A.R.N. Monuments
- NGS OPUS Solution
- Other NGS (formerly USC&GS) triangulation stations
- Existing projects

The source of the bearings is to be clearly stated in the submitted plans. (Do not make the statement “Bearings are assumed”).

H. VERTICAL CONTROL

Level datum shall be obtained from (listed from most desirable to least desirable):
- NGS (formerly USC&GS) bench marks
- Existing projects in the area
- USGS bench marks
- NGS OPUS Solution with RTK tie to bench mark (or approval).

The location of the source bench mark and the basis of level datum, i.e., NGS BM NAVD 88, USGS Quad Sheet NGVD 29, etc., is to be clearly stated in the plan notes. “Assumed” or “Arbitrary” level datum is not acceptable.

Bench marks, if not already in existence, shall be set within 500 feet of each end of the existing or proposed bridge and outside the limits of anticipated construction activities, if at all feasible. Bench marks every 500 to 750 feet along the roadways, if at all feasible. Bench marks are to be on points of permanent or semi-permanent nature. Bench marks in utility poles are considered temporary. Nails smaller than 60d will not be acceptable. Bench loop run shall be completed for all vertical control.

I. LAND TIES

Land corners are to be established, referenced and filed in both directions of the surveyed bridge or roadway (Section Corners and 1/4 Section Corners). If the Centerline of Survey is not on a Section Line or 1/4 Section Line, the points of intersection of the Centerline of Survey and the Section Line and 1/4 Section Line that it crosses are to be set and referenced and ties shown in the submitted notes.
NOTE: ODOT, Survey Division, requires that a Oklahoma Certified Corner Record form be filed on each corner used, even if it is a corner previously filed and found and used unchanged. This is to formally signify that the corner is being honored.

NOTE: All monuments set (land corners) and their references are to be in compliance with the requirements of State minimum standards.

J. PROPERTY OWNERSHIPS

Property Ownerships shall be shown and are to be obtained from local sources. Easements shall also be shown. The source shall be noted in the plans. All property and easement boundaries shall be closed.

K. EXISTING RIGHT-OF-WAY:

Existing right-of-way shall be taken from existing projects in the area or show Statutory Section Line right-of-way.

NOTE: When fence lines are parallel to the Section Lines and are outside the normal statutory right-of-way limits, you may not show the normal statutory right-of-way as the County may claim prescriptive (occupied) rights-of-way in these areas.

L. DRAINAGE INFORMATION:

1. A flowline profile of the stream is to be obtained for a minimum of 250 feet upstream and downstream.

2. Ravine sections, both upstream and downstream, are to be taken a minimum of 100 feet, or two (2) times the length of the proposed bridge, whichever is greater, from the Centerline of Survey and shall cross perpendicular to the stream. Ravine sections are to extend beyond flood plain limits. Ravine section information is to include land use, such as cultivated, pasture, timber, etc.

3. Sketch of side view of the existing bridge with dimensions.

4. Location and elevations of controls upstream and downstream such as reservoirs, pond dams, weir walls, etc. within 500 feet of Centerline of Survey.

5. Houses and Barns upstream - location and floor pad elevation within 500 feet of Centerline of Survey.
M. UTILITIES

Utility companies servicing the project area shall be contacted through “CALL OKIE” (1-800-522-6543) and/or city records and have them locate all utilities will be located to a minimum distance of 200 feet in both directions along the Centerline of Survey from the bridge within a band of 150 feet right and left of Centerline. The owner contact information, type, size and approximate depth and a statement of how the location and depth was obtained is to be shown in the plan notes.
CHAPTER 3
BASIC DESIGN CONTROLS

A. FUNCTIONAL CLASSIFICATION

The County Highway System in Oklahoma should be functionally classified as to its use and relative importance to the transportation needs of the county. This concept impacts project selection as well as project design.

B. TRAFFIC VOLUME

The design traffic volume will be based upon the road’s functional classification. All projects, not including 3R projects, on the Major and Minor Collector System will base design upon a 20-year traffic volume projection. A minimum 2% per year growth rate may be used unless other traffic factors are known. Local Roads, and 3R projects on Major and Minor collectors, may base design on the current average of a continuous seven-day traffic count to achieve an average daily traffic, ADT, count regardless of the improvement. For all bridge replacement projects use future projected traffic volume.

C. TERRAIN

The topography of the land traversed has an influence on the alignment of roads and streets. Topography does affect horizontal alignment, but it is more evident in the effect on vertical alignment. To characterize variations, engineers generally separate topography into three classifications according to terrain:

- Level terrain is that condition where highway sight distances, as governed by both horizontal and vertical restrictions, are generally long or could be made to be so without construction difficulty or major expense.

- Rolling terrain is that condition where the natural slopes consistently rise above and fall below the road or street grade and where occasional steep slopes offer some restriction to normal horizontal and vertical roadway alignment.

- Mountainous terrain is that condition where longitudinal and transverse changes in the elevation of the ground with respect to the road or street are abrupt and where benching and side hill excavation are frequently required to obtain acceptable horizontal and vertical alignment.

Terrain classifications pertain to the general character of a specific route corridor. Routes in valleys or passes of mountainous areas that have all the characteristics of roads or streets traversing level or rolling terrain should be classified as level or rolling.
In general, rolling terrain generates steeper grades, causing trucks to reduce speeds below those of passenger cars, and mountainous terrain aggravates the situation, resulting in some trucks operating at crawl speeds.

D. MINIMUM DESIGN SPEED

Geometric design features should be consistent with a design speed selected as appropriate for terrain conditions. Low design speeds are generally applicable to roads with winding alignment in rolling or mountainous terrain or where environmental conditions dictate. Higher design speeds are generally applicable to roads in level terrain or where other environmental conditions are favorable.

The design speed for a project should represent the operating speed that is expected on the completed project. Design speed is a function of the terrain on which the project is constructed and the type of surfacing to be constructed. Design speed is defined as the speed selected to control the geometric features of the project taken as a whole including features such as horizontal curvature and superelevation, stopping sight distance, passing sight distance and maximum grades. It is the speed that can be safely maintained through the project when traffic and weather conditions are so favorable that geometrics of the highway govern. On county roads there may be an occasional geometric feature (usually a horizontal curve) where conditions warrant a lower design speed. These exceptions should be communicated to the driver by a warning sign with a speed advisory plate indicating that a reduction to a certain speed is needed.

The following table gives the minimum design speed for various terrain conditions, type of surface and current or projected ADT.

<table>
<thead>
<tr>
<th>Type of Terrain</th>
<th>Design Speed (mph) for Specified Design Volume (vah/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Under 50</td>
</tr>
<tr>
<td>Level</td>
<td>30</td>
</tr>
<tr>
<td>Rolling</td>
<td>20</td>
</tr>
<tr>
<td>Mountainous</td>
<td>20</td>
</tr>
</tbody>
</table>

(Table 5-1, “Green Book”)

The designer should strive for a higher design speed for specific features of the road where they can be obtained at nominal cost. The County may post a speed limit different than the design speed if the completed road conditions warrant a change in the speed limit would be reasonable and safe. (OK ST. Title 47 § 11-803) Refer to the
current edition of the Manual on Uniform Traffic Control Devices, which indicates the proper process to decide on a speed limit.

E. HYDROLOGY (CROSS DRAINS)

All aspects of design pertaining to drainage shall be based as a minimum on a 5-year storm event (Q5). No overtopping of the roadway or shoulder (based on a 5-year storm event) will be allowed in design considerations. This criterion shall only relate to those structures less than 20’ in length, measured along the roadway centerline, not categorized as bridge structures. See Chapter 10 for details of drainage design requirements.
CHAPTER 4
HORIZONTAL ALIGNMENT

A. GENERAL INFORMATION

All geometric elements should, as far as economically practical, be designed to operate at a speed likely to be observed under normal conditions. Typically county road projects are designed with regular horizontal curves. Compound curves should be avoided as they are not aesthetically pleasing and mislead the driver’s expectations of how sharp the turn is.

This chapter consolidates many of the often-used tables, or parts of tables from AASHTO’s “Green Book”. Further discussions on side friction, passing sight distances, stopping sight distances, compound curves, spiral curves, can be found there.

B. ALIGNMENT

Alignment between control points should be designed to as high a standard as possible consistent with the environmental impacts, topography, terrain, design traffic volume, the amount of reasonably obtainable right-of-way, and the amount and cost of earthwork involved. Sudden changes between curves of widely different radii or between sharp curves should be avoided. The design should include passing opportunities if at all feasible.

The locations of cross street intersections should be considered when determining the alignment. See Chapter 7, At-Grade intersections for more discussion.

C. ROADWAY CROWN

Pavement or surfacing crown should be adequate to provide proper drainage. Normally, cross slopes should be as shown below in Table 4-1.

Table 4-1. Cross Slopes

<table>
<thead>
<tr>
<th>Surface type</th>
<th>Range in cross slope rate for a single lane (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paved</td>
<td>1.5 - 2</td>
</tr>
<tr>
<td>Unpaved</td>
<td>2 - 6</td>
</tr>
</tbody>
</table>

(Table 4-1, “Green Book”)
D. SUPERELEVATION

Superelevation is the rate of roadway cross slope expressed in percent (%). For rural roads with bituminous-type surfaces, superelevation should not be more than 10%, and an emax of 8% is typical in Oklahoma, where snow and ice are factors. Superelevation shall not exceed 6% on bridges and the preferred rate for constructability is 2% (See Chapter 12).

Depending on the maximum superelevation value, the minimum radii to be used for different design speeds are shown in Table 4-2. These minimum radii should be the exception rather than the rule. The purpose of the table given here is to assist the designer to come up with an acceptable alignment for the chosen design speed.

<table>
<thead>
<tr>
<th>emax</th>
<th>Design speed (mph)</th>
<th>Min R without super (ft)</th>
<th>With Superelevation</th>
<th>Min R ADT&lt;250 (ft)</th>
<th>Min R ADT 250 to 400 (ft)</th>
<th>Min R ADT&gt;400 (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8%</td>
<td>20</td>
<td>1640</td>
<td>60</td>
<td>60</td>
<td>76</td>
<td></td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>2370</td>
<td>105</td>
<td>105</td>
<td>134</td>
<td></td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>3240</td>
<td>105</td>
<td>105</td>
<td>214</td>
<td></td>
</tr>
<tr>
<td></td>
<td>35</td>
<td>4260</td>
<td>170</td>
<td>250</td>
<td>314</td>
<td></td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>5410</td>
<td>250</td>
<td>350</td>
<td>444</td>
<td></td>
</tr>
<tr>
<td></td>
<td>45</td>
<td>6710</td>
<td>350</td>
<td>465</td>
<td>587</td>
<td></td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>8150</td>
<td>465</td>
<td>615</td>
<td>758</td>
<td></td>
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<tr>
<td></td>
<td>55</td>
<td>9720</td>
<td>615</td>
<td>760</td>
<td>960</td>
<td></td>
</tr>
<tr>
<td>10%</td>
<td>20</td>
<td>1680</td>
<td>55</td>
<td>55</td>
<td>72</td>
<td></td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>2420</td>
<td>100</td>
<td>100</td>
<td>126</td>
<td></td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>3320</td>
<td>100</td>
<td>100</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td></td>
<td>35</td>
<td>4350</td>
<td>155</td>
<td>230</td>
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</tr>
<tr>
<td></td>
<td>40</td>
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<td>230</td>
<td>320</td>
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<td></td>
<td>45</td>
<td>6830</td>
<td>320</td>
<td>425</td>
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<td></td>
<td>50</td>
<td>8280</td>
<td>425</td>
<td>565</td>
<td>694</td>
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<td>55</td>
<td>9890</td>
<td>565</td>
<td>695</td>
<td>877</td>
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(Tables 3-10b & 3-11b, "Green Book")
(Exhibits 5 & 6, “Low Volume”)
After the alignment is determined, the designer can refer to table 4-3 for the appropriate superelevation rates. Typically, narrow paved shoulders will rotate with the travelled way. For shoulders wider than 4 feet, the shoulder breakover should not exceed 0.07 ft/ft. AASHTO Guidelines for Geometric Design of Very Low-Volume Local Roads, 2001, advises that for low volume roads, the superelevation tables from the “Green Book” should be used utilizing reduced design speeds. Table 4-3 combines Green Book tables 3-10b and 3-17b and gives the revised design speed headings from exhibits 5 & 6 in AASHTO Guidelines for Geometric Design of Very Low-Volume Local Roads, 2001. The values from the green book have been truncated in table 4.3 at the minimum radii given in the Guidelines for Very Low Volume Roads.

Superelevation runoff is the length of highway needed to accomplish the change in cross slope from a section with zero cross slope (adverse crown removed) to a fully superelevated section. These values are also in Table 4-3. The tangent runout length is the length to remove the adverse crown and can be found by entering the table at the typical section slope (usually 2.0). Spirals are not typically used in Oklahoma, particularly on county roads. Adjustments in design runoff lengths may be necessary for smooth riding, surface drainage, and good appearance.
Table 4-3. Min Radii for Design Superelevation Rates & Runoffs at Design ADT & Speeds

L = Runoff length based on a 12' lane.
R values are for emax = 8%
If R in table < actual R, move down to next line

<table>
<thead>
<tr>
<th>e(%)</th>
<th>L(ft)</th>
<th>min R(ft)</th>
<th>L(ft)</th>
<th>min R(ft)</th>
<th>L(ft)</th>
<th>min R(ft)</th>
<th>L(ft)</th>
<th>min R(ft)</th>
<th>L(ft)</th>
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<td>NC</td>
<td>932</td>
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<td>2370</td>
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<td>6710</td>
<td>8150</td>
<td>9720</td>
<td></td>
<td></td>
<td></td>
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<td>2.0</td>
<td>31</td>
<td>676</td>
<td>32</td>
<td>1190</td>
<td>32</td>
<td>34</td>
<td>37</td>
<td>20</td>
<td>44</td>
<td>4990</td>
<td>46</td>
<td>5990</td>
<td>51</td>
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<td>2.2</td>
<td>34</td>
<td>360</td>
<td>36</td>
<td>1070</td>
<td>36</td>
<td>1070</td>
<td>40</td>
<td>2130</td>
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<td>546</td>
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<td>959</td>
<td>41</td>
<td>1400</td>
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<td>701</td>
<td>187</td>
<td>901</td>
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</tr>
</tbody>
</table>

(Tables 3-10b & 3-17b, “Green Book”; Exhibits 5 & 6, “Low Volume”)
A. GENERAL INFORMATION

A driver’s ability to see ahead is needed for safe and efficient operation of a vehicle. While frequent areas with passing sight distances are desirable, it is not always practical to provide them on the county system. The designer should use good engineering judgment to exceed minimum distances while considering earthwork, cross streets, drainage, and aesthetics. This chapter consolidates many of the often-used tables, or parts of tables from AASHTO’s “Green Book”. Further discussions on passing sight distances, stopping sight distances, K values for trucks, truck-climbing lanes, can be found there.

B. GRADE

The maximum design grades to be used on county road projects shall be according to the chart below.

<table>
<thead>
<tr>
<th>Terrain</th>
<th>Design Speeds (mph)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20</td>
</tr>
<tr>
<td>Level</td>
<td>7</td>
</tr>
<tr>
<td>Rolling</td>
<td>10</td>
</tr>
<tr>
<td>Mountainous</td>
<td>12</td>
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</tbody>
</table>

(Table 6-2 for Rural Collectors, “Green Book”)  
(Note: “Local Roads” may use “Green Book” Table 5-2)

The maximum design grade should be used infrequently rather than as a value to be used in most cases. At the other extreme, for short grades less than 500ft, the maximum gradient may be 2% steeper.

C. VERTICAL CURVES

Adequate passing sight distance is desirable; however, the control factor for vertical curves shall be adequate stopping sight distance. Criteria for stopping sight distance for crest vertical curves shall be height of eye 3.5 feet and height of object 2.0 feet. For sag vertical curves a headlight sight distance longer than the stopping sight distance is required. The K values below were calculated using the calculated stopping sight distance from the “Green Book”, Table 3-1 and the crest formula on pg 3-152 and the sag formula on pg. 3-158, which are based on passenger cars. The Low Volume K
numbers for crest curves come from AASHTO’s “Low Volume”, Exhibit 12. This publication recommends using the “Green Book” for sag curves.

If designing for a road with a high percentage of trucks or recreational vehicles, this table should not be used.

**Table 5-2. Minimum Stopping Sight Distance**

<table>
<thead>
<tr>
<th>Design Speed (mph)</th>
<th>Stopping Sight Distance (ft)</th>
<th>K Value CREST ADT&lt;400</th>
<th>K Value CREST ADT&gt;400</th>
<th>K Value SAG All ADT</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>111.9</td>
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<tr>
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<td>76</td>
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<td>114.18</td>
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<td>60</td>
<td>566</td>
<td>103</td>
<td>148.45</td>
<td>134.55</td>
</tr>
</tbody>
</table>

(Table 3-1, equations on pg 3-152 & 3-158, “Green Book”)  
(Exhibit 12, “Low Volume”)

The K value is a coefficient by which the algebraic difference in grade may be multiplied to determine the length in feet of the vertical curve, which will provide the minimum sight distance. Curve lengths are usually rounded up and the minimums should be avoided if possible. A maximum K of 167 for both crest and sag curves is generally sufficient for curbed sections to allow for proper drainage.

The locations of cross street intersections should be considered when determining the vertical alignment. See Chapter 7, At-Grade Intersections, for more discussion. The sight distances available at the intersection can best be viewed graphically in the plan & profile section.
CHAPTER 6
CROSS-SECTION ELEMENTS

A. ROADWAY WIDTH

Shoulder width is measured from the edge of traveled way to the point of intersection of shoulder slope and foreslope. The minimum roadway width is the sum of the traveled way and shoulder width given below. In mountainous terrain or sections with heavy earthwork the graded width of shoulder in cuts may be decreased by up to 2 feet, but in no case should the roadway width be less than 18 feet.

Table 6-1. Width (ft) for Design Volumes

<table>
<thead>
<tr>
<th>Design Speed (mph)</th>
<th>ADT Less than 250</th>
<th>ADT 250 - 399</th>
<th>ADT 400 - 1599</th>
<th>ADT 1600 - 2500</th>
</tr>
</thead>
<tbody>
<tr>
<td>20*</td>
<td>18</td>
<td>20</td>
<td>20</td>
<td>22</td>
</tr>
<tr>
<td>30</td>
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<tr>
<td>50</td>
<td>20</td>
<td>20</td>
<td>22</td>
<td>24</td>
</tr>
</tbody>
</table>

(* May be used for spot locations only)

(State of Oklahoma County Roads Design Guidelines Manual, pg. V-1)

B. SIDESLOPES

Slopes should be as flat as feasible. Recoverable foreslopes increase safety by providing maneuver area in emergencies, are more stable than steep slopes, aid in the establishment of plant growth, and simplify maintenance work. Vehicles that leave the traveled way can often be kept under control if slopes and drainage ditches are recoverable. Such recovery areas should be provided where terrain and right-of-way controls permit.

Combinations of rate and height of slope should provide for vehicle recovery. Where controlling conditions (such as high fills, right-of-way restrictions, or the presence of rocks, watercourses, or other hazards) make this impractical, an analysis shall be performed to determine the proper method of treatment. See Chapter 8 and Roadside Design Guide for additional discussions of this analysis.
Cut sections should be designed with adequate ditches to promote proper drainage. The foreslope within the clear zone shall not be steeper than 1V:3H unless protected by guardrail. Shoulders shall be widened to accommodate guardrail to provide a uniform width of traveled way and outside shoulders. The backslope shall not exceed the maximum required for stability, maintenance, right-of-way and utility restrictions, clear zone, and safety.

The Special Provision 411-14(a-b)09, Asphalt Safety Edge, should be included as it will apply to most county projects where the paved shoulder is 4 feet or less.

C. DITCHES

As a minimum, ditches shall have a cross-sectional area adequate to handle a 5 year flood (Q5). The elevation of the bottom of the ditch shall be a minimum of 1.0 ft. below the subgrade shoulder. The minimum desirable grade for drainage ditches should be 0.5 % in order to avoid sedimentation but may be designed as flat as 0.4% as the minimum slope for grassed channels and 0.2% for concrete lined channels to meet site conditions. The maximum grade should be based on a tolerable velocity for vegetation and shear on soil types. See Chapter 10 for additional discussions. Ditch slopes greater than 3% (or velocities greater that 8 ft/sec should consider erosion control techniques such as paved ditch liner, riprap lined ditches, ditch checks, wider ditch bottoms, etc. Rounded or flat bottom ditches are preferred. V-ditches may be used in areas with limited right-of-way. Interceptor ditches should be used areas of steep backslopes and hillsides.
A. SIGHT DISTANCE

Intersections should be carefully situated to avoid steep profile grades and to ensure adequate approach sight distance. Intersections are not well situated on short-crest vertical curves, just beyond a short-crest vertical curve, or on a sharp horizontal curve. When there is no practical alternate to such a location, the approach sight distance on each leg should be checked carefully. Where necessary, backslopes should be flattened and horizontal or vertical curves lengthened to provide additional sight distance. Sight distance should be sufficient to permit a vehicle on the minor leg of the intersection to cross the traveled way without requiring the approaching through traffic to slow down. The suggested corner sight distance for each design speed would be as given in the table below.

<table>
<thead>
<tr>
<th>Design Speed (mph)</th>
<th>Stopped Passenger Car Turning Left Design Distance (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>225</td>
</tr>
<tr>
<td>25</td>
<td>280</td>
</tr>
<tr>
<td>30</td>
<td>335</td>
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<td>35</td>
<td>390</td>
</tr>
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<td>555</td>
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<td>55</td>
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<td>665</td>
</tr>
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<td>65</td>
<td>720</td>
</tr>
</tbody>
</table>

(Table 9-6, “Green Book”)

Note: Intersection sight distance shown is for a stopped passenger car to turn left onto a two-lane highway with no median and grades 3 percent or less. For other conditions, the time gap must be adjusted and required sight distance recalculated.
Where practical, it is desirable to increase the Corner Intersection Sight Distance especially where higher volumes of trucks are present.

### Table 7-2. Truck Intersection Sight Distance

<table>
<thead>
<tr>
<th>Design Speed (mph)</th>
<th>Corner Intersection Sight Distance (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Single Unit Truck</td>
</tr>
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<td>280</td>
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<tr>
<td>60</td>
<td>840</td>
</tr>
<tr>
<td>65</td>
<td>910</td>
</tr>
</tbody>
</table>

(Equation 9-1, pg. 9-37, “Green Book”)

For additional information for the calculation of corner intersection sight distance, see Chapter 9 of the AASHTO “Policy on Geometric Design of Highways and Streets”. If the recommended Corner Intersection Sight Distances cannot be met, the intersection should be changed to a full stop controlled intersection with the introduction of proper traffic control devices.

**B. TURNING RADIUS**

Intersections should be designed with a pavement corner radius that is adequate for anticipated truck traffic to minimize trucks crossing over into adjacent lane. See the Chapter 9 of the AASHTO “Policy on Geometric Design of Highways and Streets” for turning paths.

Intersection legs that operate under stop control preferably should be 90° if possible, but should be no less than 60°.

Minimum Edge Radius of 25 feet shall be used.
A. CLEAR ZONE

Clear Zone is the distance from the edge of the driving lane to an obstacle. The probability of vehicle departure from the driving lane increases as traffic volumes rise. The minimum clear zone width of 2’ is required on all projects. Refer to the current version of AASHTO’s Roadside Design Guide for further details.

<table>
<thead>
<tr>
<th>Design ADT</th>
<th>Width (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 399</td>
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<tr>
<td>400 – 2500</td>
<td>7 - 10</td>
</tr>
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</table>

(Pg. 49, “Low Volume”; Pg 5-8, “Green Book”)

As an alternative to using the table values above, the designer may use two methods to reduce the clear zone widths. The first method, a designer may use a cost-effectiveness analysis that assesses the appropriate roadside design. A NCHRP program, Roadside Safety Analysis (RSAP), is one analysis that compares alternate safety treatments and provides guidance in selecting a design. In the second method the designer may request a design exception that is approved by the Oklahoma Department of Transportation.

B. GUARDRAIL END TREATMENTS

For all projects under 400 design ADT, the designer may use a guardrail anchor unit, a turn down end treatment, on the leading edge of guardrail. (1999 ODOT Roadway Standard GRAU1-1) Remember to include a delineator as shown on the standard at the end.

Over 400 design ADT shall require on the leading edge of guardrail, a crash tested end treatment, NCHRP 350. (Refer to current ODOT Traffic Safety Standard)
CHAPTER 9
GEOMETRIC DESIGN CRITERIA

A. GENERAL INFORMATION

The notes below shall apply to the table found on the following page. This table serves as a useful quick reference guide for minimum new design values on new and reconstruction projects. The engineer should make every effort to exceed these minimums where project attributes, such as costs, are not greatly affected. On 3R projects existing design values/geometrics may be used after investigating safety improvements through traffic counts and accident studies.

(1) **Design Year.**  Recommended that on Major / Minor collector system a 20-year projection be used.

(2) **Design Speed.**  The design speed should equal or exceed the anticipated posted or regulatory speed limit after construction.

(3) **Shoulder Width.**  All shoulder widths refer to the graded width, which is the distance between the edge of the travel lane and the point of intersection of the shoulder slope and the side slope.

(4) **Right-of-Way Width.**  The minimum Right-of-Way width will be the sum of the travel lane width, the necessary width for fill and cut slopes, and width needed for parallel utility. (unless utility easement option is used)

(5) **Clear Zone.**  See Chapter 8.

(6) **Back Slopes.**  Back slopes should be flat as possible and not any steeper than 1(V):2(H) for maintenance activities, but may be as steep as 1(V):1/4(H) in rock cuts

(7) **Minimum Radius for ADT>400 / Superelevation Rate.**  The values provided in the table are based on a emax=.08, which will apply in most cases. See Chapter 4 for lower ADT.

(8) **Vertical Curvature (K-Values).**  Values in the table are minimums for ADT > 400. See Chapter 5.

(9) **Structural Capacity.**  Title 69 Sec. 662, "County Built" project must be a min. H-23 operating rating.

(10) **Bridge Width.**  Title 69 Sec. 662, "County Built" project must be a min. 24' wide.
Table 9-1. Minimum Geometric Design Criteria

<table>
<thead>
<tr>
<th>Design Element</th>
<th>Manual Section</th>
<th>ADT &lt;50</th>
<th>ADT 50-250</th>
<th>ADT 250-400</th>
<th>ADT 400-1500</th>
<th>ADT 1500-2000</th>
<th>ADT 2000-2500</th>
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<td>Minimum Grade</td>
<td>Desirable 0.5%; Minimum 0.0%</td>
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<td>Existing Bridges to Remain in Place</td>
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<td>H-15</td>
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<td>Width</td>
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<td>ADT 400-1500</td>
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<td>H-25</td>
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<td></td>
<td>ADT 2000-2500</td>
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</tr>
</tbody>
</table>
A. STORM FREQUENCY

All drainage for county road project shall be computed using no less than the 5 year rainfall frequency curves unless the area served dictates the use of a greater return frequency.

B. DESIGN METHODOLOGY

General guidelines for Q calculation methods:
1. USGS Method for 1 sq.mile < drainage area < 2,510 sq.miles; see “Techniques for Estimating Peak-Streamflow Frequency for Unregulated Streams and Streams Regulated by Small Floodwater Retarding Structures in Oklahoma” by U.S. Geological Survey and Water-Resources Investigations Report 97-4202. Calculation aids are available at:
   http://water.usgs.gov/osw/streamstats/oklahoma.html

2. SCS Method for 200 acres < drainage area < 640 acres; see “NEH-Part 630-Hydrology” for SCS Method. (NEH = National Engineering Handbook and Part 630 is the hydrology section. Link to NEH manual:


Further guidance for the Rational Method is included below:

The Rational Method may be used to compute the design flows for all structures less than those classified as Bridge Structures, i.e. 20 feet or more in span. This method is given in the formula:

\[ Q = C \times I \times A \]

where,
- \( Q \) = total flow in cfs
- \( C \) = runoff coefficient, see Table 10-5.
- \( I \) = intensity in inches /hour. See Tables 10-3 and 10-4.
- \( A \) = area of the drainage basin in acres and is less than 200 acres.

The runoff coefficient, \( C \), is a factor used to modify the amount of runoff from an area under consideration because of surface conditions which change the drainage characteristics. This coefficient, \( C \), is a factor which decreases the total runoff from
100%. Table 10-5 is included with a range of values for the most anticipated conditions.

The Time of Concentration is determined and from that the intensity, I, is calculated. The Time of Concentration is the time required for water to flow from the most remote part of the watershed to the drainage structure and is broken into two parts: time for overland flow and time for channel flow. Formula for Time of Concentration is:

\[ T_c = T_o + T_f \]

where,

- \( T_c \) = total time of concentration
- \( T_o \) = time of flow overland to the channel
- \( T_f \) = time of flow through the channel to the drainage structure

The Time of Concentration of overland flow, \( T_o \), can be computed by:

\[ T_o = k \left( \frac{L_o}{S_o} \right)^{0.37} \]

where,

- \( T_o \) = Time of Concentration in minutes
- \( L_o \) = Length of the overland flow in feet
- \( S_o \) = slope in feet / feet
- \( k \) = a coefficient dependant on ground cover, see Table 10-1.

<table>
<thead>
<tr>
<th>Ground Cover Material</th>
<th>K</th>
</tr>
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<tbody>
<tr>
<td>Concrete/asphalt</td>
<td>0.372</td>
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<tr>
<td>Commercial development</td>
<td>0.445</td>
</tr>
<tr>
<td>Residential development</td>
<td>0.511</td>
</tr>
<tr>
<td>Rocky, bare soil</td>
<td>0.604</td>
</tr>
<tr>
<td>Cultivated soil</td>
<td>0.775</td>
</tr>
<tr>
<td>Woodlands, thin grass</td>
<td>0.942</td>
</tr>
<tr>
<td>Average pasture</td>
<td>1.040</td>
</tr>
<tr>
<td>Tall grasses</td>
<td>1.130</td>
</tr>
</tbody>
</table>

Time of Concentration for channel flow, \( T_f \), can be computed by:

\[ T_f = k' \left( \frac{L_f}{S_f} \right)^{0.77} \]

where,

- \( T_f \) = Time of Concentration in minutes
- \( L_f \) = channel length in feet
- \( S_f \) = channel slope in feet / feet
- \( k' \) = a coefficient dependant on type of channel, see Table 10-2.
<table>
<thead>
<tr>
<th>Channel condition</th>
<th>K’</th>
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<td>Straight, clean stream</td>
<td>0.00592</td>
</tr>
<tr>
<td>Average stream, few obstructions</td>
<td>0.00835</td>
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<tr>
<td>Meandering stream w/pools</td>
<td>0.01020</td>
</tr>
<tr>
<td>V-ditch</td>
<td>0.01252</td>
</tr>
</tbody>
</table>

With the time of concentration calculate the intensity from:

\[ I = \frac{a}{(To + b)^c} \]

where,

values of a, b, and c are found in Table 10-4 for each zone in the state of Oklahoma and the different zones are found in Table 10-3 on the next page.
Table 10-3
Oklahoma’s Five Geographical Zones for Hydraulics

<table>
<thead>
<tr>
<th>ZONE 1</th>
<th>2 Year</th>
<th>5 Year</th>
<th>10 Year</th>
<th>25 Year</th>
<th>50 Year</th>
<th>100 Year</th>
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<td>a</td>
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<td>69</td>
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<tr>
<td>c</td>
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<td>a</td>
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<td>c</td>
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<tr>
<td>Railroad yard areas</td>
<td>0.20-0.40</td>
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<tr>
<td>Unimproved areas</td>
<td>0.10-0.30</td>
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<tr>
<td><strong>Streets:</strong></td>
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<tr>
<td>Asphalt</td>
<td>0.70-0.95</td>
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<tr>
<td>Concrete</td>
<td>0.80-0.95</td>
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<tr>
<td>Brick</td>
<td>0.70-0.85</td>
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<tr>
<td>Drives and walks</td>
<td>0.75-0.85</td>
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<tr>
<td>Roofs</td>
<td>0.75-0.85</td>
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<tr>
<td><strong>Lawns:</strong></td>
<td></td>
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</tr>
<tr>
<td>Sandy soil, flat – 2%</td>
<td>0.05-0.10</td>
<td></td>
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</tr>
<tr>
<td>Sandy soil, average 2%-7%</td>
<td>0.10-0.15</td>
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<tr>
<td>Sandy soil, steep 7%</td>
<td>0.15-0.35</td>
<td></td>
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<tr>
<td>Heavy soil, flat – 2%</td>
<td>0.13-0.17</td>
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<tr>
<td>Heavy soil, average 2%-7%</td>
<td>0.18-0.22</td>
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<tr>
<td>Heavy soil, steep 7%</td>
<td>0.25-0.35</td>
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<tr>
<td><strong>Agricultural land:</strong></td>
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<tr>
<td>Bare, packed soil, smooth</td>
<td>0.30-0.60</td>
<td></td>
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<tr>
<td>Bare, packed soil, rough</td>
<td>0.20-0.50</td>
<td></td>
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<tr>
<td>Cultivated rows:</td>
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<tr>
<td>Heavy soil, no crop</td>
<td>0.30-0.60</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Heavy soil with crop</td>
<td>0.20-0.50</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Sandy soil, no crop</td>
<td>0.20-0.40</td>
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<tr>
<td>Sandy soil with crop</td>
<td>0.10-0.25</td>
<td></td>
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<tr>
<td><strong>Pasture:</strong></td>
<td></td>
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</tr>
<tr>
<td>Heavy soil</td>
<td>0.15-0.45</td>
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<tr>
<td>Sandy soil</td>
<td>0.05-0.25</td>
<td></td>
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<tr>
<td>Woodlands</td>
<td>0.05-0.25</td>
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</table>
C. OPEN CHANNEL FLOW

Highway ditches and drainage channels shall be designed using the Mannings formula:
\[ Q = \frac{1.49}{n} (A)(R^{2/3})(S^{1/2}) \]
where,  
\[ Q = \text{discharge in cubic feet per second, cfs} \]
\[ A = \text{area of the channel section in square feet, sq.ft.} \]
\[ n = \text{roughness coefficient, see Table 10-6.} \]
\[ R = \text{hydraulic radius in feet, } R = \frac{\text{Area}}{\text{wetted perimeter}} \]
\[ S = \text{slope of channel in feet per feet, ft/ft} \]

This formula should also be used to compute flow through culverts behaving as open channels. The maximum desirable velocity should not exceed 8 ft/sec in any open channel under optimum conditions and velocities less than 3 ft/sec should be avoided to prevent the settling of solids suspended in storm water effluent.

D. CULVERT DESIGN

Drainage culverts for cross drains may be designed using the Manning’s Equation for open channel flow. When the engineer warrants a more detailed analysis the culvert shall be designed according to methods as set forth in the FHWA’s HY-8 or the ODOT Roadway Design Manual, Hydraulics Section. The HY-8 Culvert Analysis and Design Program may be downloaded at:


Side drains shall not be less than 18 inches in equivalent diameter and cross drains shall not be less than 24 inches in equivalent diameter. As with the channels and ditches, the culverts shall be sized to provide optimum flow rates for soil conditions.

**Highly recommend concrete to be used for cross drains.**
### Table 10-6

**ROUGHNESS COEFFICIENTS FOR USE IN MANNING EQUATION (1) (4)**

<table>
<thead>
<tr>
<th>I. Closed Conduits (2)</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>A. Concrete Pipe</td>
<td>0.011-0.013</td>
<td></td>
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<tr>
<td>B. Corrugate metal pipe or pipe arch</td>
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<tr>
<td>1. 2 2/3&quot; x 1 1/2&quot; corrugation (riveted pipe) (3)</td>
<td></td>
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<tr>
<td>a. Plain or fully coated</td>
<td>0.024</td>
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<tr>
<td>b. Paved invert (25% and 50% paved)</td>
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<tr>
<td>(1) Flow full depth</td>
<td>0.021-0.018</td>
<td></td>
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<tr>
<td>(2) Flow 0.8 depth</td>
<td>0.021-0.016</td>
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<tr>
<td>(3) Flow 0.5 depth</td>
<td>0.027</td>
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<tr>
<td>2. 2&quot; x 1&quot; corrugation</td>
<td>0.027</td>
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<tr>
<td>3. 6&quot; x 2&quot; corrugation (field bolted)</td>
<td>0.032</td>
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<tr>
<td>C. Vitrified clay pipe</td>
<td>0.012-0.104</td>
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<tr>
<td>D. Cast-iron pipe, uncoated</td>
<td>0.013</td>
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<tr>
<td>E. Steel pipe</td>
<td>0.009-0.011</td>
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<tr>
<td>F. Brick</td>
<td>0.014-0.017</td>
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<tr>
<td>G. Monolithic Concrete</td>
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<tr>
<td>1. Wood forms, rough</td>
<td>0.015-0.017</td>
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<tr>
<td>2. Wood forms, smooth</td>
<td>0.012-0.014</td>
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<tr>
<td>3. Steel forms</td>
<td>0.012-0.013</td>
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<tr>
<td>H. Cemented rubble masonry walls</td>
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<tr>
<td>1. Concrete floor and top</td>
<td>0.017-0.022</td>
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<tr>
<td>2. Natural floor</td>
<td>0.019-0.025</td>
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<tr>
<td>I. Laminated treated wood</td>
<td>0.015-0.017</td>
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<tr>
<td>J. Vitrified clay liner plates</td>
<td>0.015</td>
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<tr>
<td><strong>II. Lined Open Channels (2)</strong></td>
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<tr>
<td>A. Concrete, with surfaces indicated:</td>
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<tr>
<td>1. Formed, no finish</td>
<td>0.013-0.017</td>
<td></td>
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</tr>
<tr>
<td>2. Trowel finish</td>
<td>0.012-0.014</td>
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<tr>
<td>3. Float finish</td>
<td>0.013-0.015</td>
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<tr>
<td>4. Float finish, some gravel on bottom</td>
<td>0.016-0.017</td>
<td></td>
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<tr>
<td>5. Gunite, good section</td>
<td>0.016-0.019</td>
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<tr>
<td>6. Gunite, wavy section</td>
<td>0.018-0.022</td>
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<tr>
<td>B. Concrete bottom float finished sides as indicated:</td>
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<tr>
<td>1. Dressed stone in mortar</td>
<td>0.015-0.017</td>
<td></td>
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<tr>
<td>2. Random stone in mortar</td>
<td>0.020-0.025</td>
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</tr>
<tr>
<td>3. Cement rubble masonry</td>
<td>0.020-0.025</td>
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<tr>
<td>4. Cement rubble masonry, plastered</td>
<td>0.016-0.020</td>
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<tr>
<td>5. Dry rubble (rip rap)</td>
<td>0.020-0.030</td>
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<tr>
<td>C. Gravel bottom, sides as indicate:</td>
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<tr>
<td>1. Formed concrete</td>
<td>0.107-0.020</td>
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<tr>
<td>2. Random stone in mortar</td>
<td>0.020-0.023</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>3. Dry rubble (rip rap)</td>
<td>0.023-0.033</td>
<td></td>
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<tr>
<td>D. Brick</td>
<td>0.014-0.017</td>
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<tr>
<td>E. Asphalt</td>
<td></td>
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</tr>
<tr>
<td>1. Smooth</td>
<td>0.013</td>
<td></td>
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<tr>
<td>2. Rough</td>
<td>0.016</td>
<td></td>
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<tr>
<td>F. Wood, planed, clean</td>
<td>0.011-0.013</td>
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<tr>
<td>G. Concrete lined excavated rock:</td>
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<tr>
<td>1. Good section</td>
<td>0.017-0.020</td>
<td></td>
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<tr>
<td>2. Irregular section</td>
<td>0.022-0.027</td>
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<tr>
<td><strong>III. Unlined Open Channels (2)</strong></td>
<td></td>
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</tr>
<tr>
<td>A. Earth uniform section,</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>1. No vegetation</td>
<td>0.022-0.025</td>
<td></td>
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</tr>
<tr>
<td>2. Grass, some weeds</td>
<td>0.025-0.030</td>
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<tr>
<td>3. Dense weeds or aquatic plants in deep channels</td>
<td>0.030-0.035</td>
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</tr>
<tr>
<td>4. Sides, clean, gravel bottom</td>
<td>0.025-0.030</td>
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<tr>
<td>5. Sides, clean, cobble bottom</td>
<td>0.030-0.040</td>
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<tr>
<td>B. Earth, fairly uniform section,</td>
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<tr>
<td>1. No vegetation</td>
<td>0.028-0.033</td>
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<tr>
<td>2. Light brush on banks</td>
<td>0.035-0.050</td>
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<tr>
<td>C. Dragline excavated or dredged,</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>1. No vegetation</td>
<td>0.028-0.033</td>
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<tr>
<td>2. Light brush on banks</td>
<td>0.022-0.025</td>
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<tr>
<td>D. Rock,</td>
<td></td>
<td></td>
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<tr>
<td>1. Based on design section</td>
<td>0.035</td>
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<tr>
<td>2. Based on actual mean section,</td>
<td>0.035-0.040</td>
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<tr>
<td>a. Smooth and uniform</td>
<td>0.035-0.040</td>
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<tr>
<td>b. Jagged and irregular</td>
<td>0.040-0.045</td>
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<tr>
<td>E. Channels not maintained, weeds and brush uncut,</td>
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<tr>
<td>1. Dense weeds, high as flow depth</td>
<td>0.080-0.012</td>
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</tr>
<tr>
<td>2. Clean bottom, brush on sides</td>
<td>0.050-0.080</td>
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<tr>
<td>3. Clean bottom brush on sides, highest stage of flow</td>
<td>0.070-0.011</td>
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<tr>
<td>4. Dense brush, high stage</td>
<td>0.100-0.140</td>
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<tr>
<td><strong>IV. Street and Expressway Gutters:</strong></td>
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</tr>
<tr>
<td>A. Concrete gutter, trowel finish</td>
<td>0.012</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. Asphalt pavement,</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>1. Smooth texture</td>
<td>0.013</td>
<td></td>
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<tr>
<td>2. Rough texture</td>
<td>0.016</td>
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<tr>
<td>C. Concrete gutter with asphalt pavement,</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Smooth</td>
<td>0.013</td>
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<tr>
<td>2. Rough</td>
<td>0.015</td>
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<tr>
<td>D. Concrete pavement,</td>
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<td></td>
</tr>
<tr>
<td>1. Float finish</td>
<td>0.014</td>
<td></td>
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<tr>
<td>2. Broom finish</td>
<td>0.016</td>
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</tr>
</tbody>
</table>

E. For gutters with small slope, where sediment may accumulate, increase all above values of n by 0.002

V. Highway Channels and Swales With Maintained Vegetation (values show are for velocities of 2 and 6 f.p.s.).

A. Depth of flow up to 0.7 feet

1. Bermuda grass, Kentucky bluegrass, buffalo grass,
   a. Mowed to 2 inches | 0.070-0.045 |
   b. Length 4 to 6 inches | 0.090-0.050 |

2. Good stand, any grass,
   a. Length about 12 inches | 0.180-0.090 |
   b. Length about 24 inches | 0.300-0.150 |

3. Fair stand, any grass,
   a. Length about 12 inches | 0.140-0.080 |
   b. Length about 24 inches | 0.250-0.130 |

B. Depth of flow 0.7-1.5 feet

1. Bermuda grass, Kentucky bluegrass, buffalo grass,
   a. Mowed to 2 inches | 0.050-0.350 |
   b. Length 4 to 6 inches | 0.060-0.040 |

2. Good stand, any grass,
   a. Length about 12 inches | 0.120-0.070 |
   b. Length about 24 inches | 0.200-0.100 |

3. Fair stand, any grass,
   a. Length about 12 inches | 0.100-0.060 |
   b. Length about 24 inches | 0.170-0.090 |

VI. Natural Stream Channels, (3)

A. Minor streams (surface width at flood stage less than 100 feet)

1. Fairly regular section,
   a. Some grass and weeds, little or no brush | 0.030-0.035 |
   b. Dense growth of weeds, depth of flow materially greater than weed height | 0.035-0.050 |
   c. Some weeds, light brush on banks | 0.040-0.050 |
   d. Some weeds, heavy brush on banks | 0.050-0.070 |
   e. Some weeds, dense willows on banks | 0.060-0.080 |
   f. For trees within channel, with branches submerged at high stage, increase all above values by | 0.010-0.100 |

C. Major streams (surface width at flood stage more than 100 feet), Roughness coefficient is usually less than for minor streams of similar description on account of less effective resistance offered by irregular banks or vegetation on banks. Values of n may be somewhat reduced. Follow recommendation of note 7 if possible. The value of n for larger streams of most regular sections, with no boulders of brush, may be in the range of from | 0.028-0.033 |
Table 10-6 Footnotes:

(1) Estimates are by Bureau of Public Roads (FHWA) unless otherwise noted and are for straight alignment. A small increase in value of n may be made for channel alignment other than straight.

(2) Ranges for section I through III are for good to fair construction. For poor quality construction use larger values of n.

(3) The tentative values of n cited are principally derived from measurements made on fairly short but straight reaches of natural streams. Where slopes calculated from flood elevations along a considerable length of channel, involving meanders and bends, are to be used in velocity calculations by the Manning formula, the value of n must be increased to provide for the additional loss of energy caused by beds. The increase may be in the range of perhaps 3% to 15%.

(4) The presence of foliage on trees and brush under flood stage will materially increase the value of n. Therefore, roughness coefficients for vegetation in leaf will be larger than for bare branches. For trees in channels or on banks, and for brush on banks where submergence of branches increases with depth of flow, n will increase with rising stage.
CHAPTER 11
PAVEMENT DESIGN

A. GENERAL INFORMATION

Typical projects for county roads can be broken down into three major categories. The first type of project would be bridge replacement projects with short approach roadway sections. The second type of project would be longer roadway paving projects. These longer roadway projects may include one or more bridge structure(s) but the roadway design effort is a large part of the design effort. The third type of project would be mainly structural overlays. For the shorter projects the designer may elect to use either the current AASHTO program like DARWin Mechanistic-Emperical (M.E) program, OSI or some other recognized pavement design method. For the longer projects, or those projects with a higher percentage of truck traffic, the designer is encouraged use a design method like the AASHTO program DARWin Mechanistic-Emperical (M.E). Designers may still continue to utilize other recognized design methods including the Oklahoma Subgrade Index (OSI) method. Overlay project designs should use the most appropriate method.

Pavement design, collection of data, data summary and calculations may be completed by a geotechnical firm hired as a subcontractor by the Design Engineer.

Designers may need to consult the Geotechnical Investigation, Chapter 13, for further consideration.

B. DESIGN CONSIDERATION

- A current or projected ADT count and percentage and type of truck loadings will be necessary for any design. (Note oil field traffic, agriculture, industrial, mining and aggregate production)
- Soil Types and properties obtained from one or more of the following
  - Bridge Borings
  - Roadway Borings
  - Oklahoma Soil Classification Charts
- Length of Project
  - Bridge with short approaches
  - Large roadway projects
  - Overlay only
C. COMPUTATIONAL METHODS FOR PAVEMENT THICKNESS

- DARWin ME (Or most current AASHTO sponsored program)
- Oklahoma Subgrade Index (OSI)
- Other professionally recognized pavement design methods

D. OKLAHOMA SUBGRADE INDEX (OSI) METHOD

The OSI method is described in detail in “Oklahoma Department of Highways Office of Design Policies and Procedures” and examples contained herein. The only additional information necessary for this design method is the selection of design wheel load. This selection is to be made based upon actual traffic counts with a clear breakdown that includes numbers of trucks and overloads. For ADT’s greater than 400, the minimum design wheel load used will be 7,000 lb. For ADT’s less than 400, where traffic counts have been certified by the consultant to justify less than a 7,000 lb. design wheel load and the County has requested by official resolution the use of less than 7,000 lb. design load, an equivalent base thickness (EBT) of 2” less than that for a 7,000 lb. design wheel load may be used. In no case shall the EBT be less than 6”. In using the OSI method care must be taken to include appropriate adjustment factors for materials, shoulders, overloaded axles and wet-dry cycles. Use of either the formula or nomograph is at the discretion of the engineer.

1. Formula Procedure:

\[ X_0 = 48.37940 \times X_1 - 0.09505 \times X_2 + 445.95413 \times X_3 - 4.58581 \times X_4 + 1.70678 \times X_5 + 14.86333 \times X_6 - 186.76322 \]

\[ X_0 = \text{Depreciation at age 10 years in percent (use 50 for most projects)}. \]

\[ T_b = \text{Required equivalent base thickness, determined from the Oklahoma subgrade index number of the subgrade and wheel load}. \]

\[ T_p = \text{Adjusted equivalent base thickness, determined from the constructed thicknesses of the pavement courses and the equivalence factors of materials}. \]

\[ X_1 = \ln (T_b + 20 - T_p). \]

\[ X_2 = (T_b - T_p) \text{ multiplied by the shoulder factor}. \]

\[ X_3 = \text{Benkelman beam deflection (Use 0.040)}. \]

\[ X_4 = \text{The square root of the shoulder factor}. \]
\( X_5 \) = Square root of the number of overloaded axles per day.

\( X_6 \) = Square root of the wet-dry climatic cycles in the ten year.

The following is an example of the use of the equation for road project in Adair County:

Design wheel load: 7,000 pounds

Design life: 20 years; therefore \( X_0 = 50 \)

Assumed allowable Benkelman beam deflection = 0.04

Soil analysis: PI = 13, LL = 30, % pass no. 200 sieve = 83 therefore: OSI = 11 (From Exhibit 11-1)

Required equivalent base thickness (\( T_b \)) (From Exhibit 11-2) EBT = 9

Shoulder factor: 0 (Exhibit 11-3, dirt shoulders)

Traffic data: ADT = 350

Heavy commercial traffic = 15% ADT

Overloaded axles = 15% heavy commercial traffic

Therefore: Traffic factor = 350 x .15 x .15 = 7.875

Climatic factor: 29 (See Exhibit 11-4)

Adjusted equivalent base thickness (\( T_p \)) to be determined

\[
50 = 48.37940 \ln (9 + 20 – T_p) - .09505 (9 – T_p) 0
+ 445.96413 (0.04) – 4.58581 (0) + 1.70678 (\sqrt{7.875})
+ 14.86333 (\sqrt{29}) – 186.76322
\]

\[
= 48.37940 \ln (29 – T_p) – 0 + 17.83817 – 0 + 4.78963
+ 80.04148 – 186.76322
\]

\[
= 48.37940 \ln (29 – T_p) – 84.09394
\]

\[
\ln (29 – T_p) = (50 + 84.09394) / 48.37940 = 2.771715
\]

by trial and error:

If: \( T_p = 10 \) \( \ln (29 – T_p) = 2.94444 \)

\( T_p = 11 \) \( \ln (29 – T_p) = 2.89037 \)

\( T_p = 12 \) \( \ln (29 – T_p) = 2.83321 \)

\( T_p = 13 \) \( \ln (29 – T_p) = 2.77259 \)

The solution is to use an adjusted EBT of 13".
If we change the typical to have stabilized aggregate shoulders without surfacing, the shoulder factor changes to 2.

\[
50 = 48.37940 \ln (9 + 20 - T_p) - .09505 (9 - T_p)^2 \\
+ 445.95413 (0.04) - 4.58581 (\sqrt{2}) + 1.70678 (\sqrt{7.875}) \\
+ 14.87333 \sqrt{29 - 186.76322}
\]

\[
= 48.37940 \ln (9 + 20 - T_p) - 1.7109 + .09505 T_p + 17.83817 \\
- 6.48531 + 4.789639 + 80.04148 - 186.76322
\]

\[
50 = 48.37940 \ln (9 + 20 - T_p) + .09505 T_p - 92.29041
\]

\[
142.29041 = 48.37940 \ln (29 - T_p) + .09505 T_p
\]

\[
2.941130 = \ln (29 - T_p) + .001964079 T_p
\]

If:

\[
T_p = 9 \quad X_1 + .001964T = 3.013414 \\
T_p = 10 \quad X_1 + .001964T = 2.9641130 \\
T_p = 11 \quad X_1 + .001964T = 2.91198
\]

Use EBT adjusted to 11"

2. Nomograph Procedure:

Using the nomograph to determine adjusted EBT

From Exhibit 11-5 the shoulder rating factor = 2.905

This value falls between 1" and 2" of correction on the table in Exhibit 11-6.

Therefore use an adjustment of 2"

Hence, EBT adjusted – 9" + 2" = 11"

Note: the nomograph will not work for shoulder factors less than 2.
OKLAHOMA SUBGRADE INDEX NUMBERS CHART

1. Determine the percent of soil passing the number 200 sieve and the L.L. and P.L. of the soil.
2. On the L.L. chart, find the % pass no. 200 along the bottom of the chart and move vertically up to the L.L. (sloping) line.
3. From the intersection of these lines, move horizontally to the left to determine index number.
4. Follow a similar procedure (reading down and right) and determine the index number from the P.I. chart.
5. The sum of the index numbers determined in steps 3 & 4 is the OSI number.
EXHIBIT 11-2

DESIGN CHART FOR OKLAHOMA SUBGRADE INDEX NUMBER

To Use This Chart

1. Determine the OSI number of the soil from the OSI number chart.
2. Find the OSI number along the bottom of the chart and follow the vertical line up to the appropriate wheel load line.
3. From the intersection of those lines, move horizontally to the left to determine the required equivalent base thickness.
### EXHIBIT 11-3

**SHOULDER FACTORS**

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EXHIBIT 11-5

NOMOGRAPH FOR DETERMINATION OF STC FACTOR

Notes:
1. See Exhibit 11-6.
2. STC factor is the product of the shoulder, traffic and climate factors.
### EXHIBIT 11-6

#### DESIGN EQUATION SOLUTION

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<td>2.197</td>
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<td>+16</td>
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<td>1.888</td>
<td>1.919</td>
<td>1.950</td>
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</tbody>
</table>
3. Flexible Pavements

**Relative Strengths:** The Oklahoma design charts are based on equivalent base thickness (EBT). In using materials of different quality, the following conversions are used:

- 1” of Asphalt Concrete = 1 ½” of EBT
- 1” of Aggregate Base = 1” of EBT
- 1” of Fine Aggregate Bituminous Base = 1” of EBT
- 1” of Coarse Aggregate Bituminous Base = 1 ¼” of EBT
- 1” of Soil Asphalt Base = 1” of EBT
- 1” of Cement Treated Base = 1” of EBT
- 1” of Subbase (Type I, II or III) = ½” of EBT
- 1” of Lime Treated Subgrade (6” Treatment) = ½” – ¾” of EBT
- 1” of Fly Ash Treated Subgrade (6” Treatment) = ½” – ¾” of EBT
A. GENERAL INFORMATION

The design of county bridges must be done with due consideration of the user. Most county bridges should be able to remain in service for 50 to 75 years with minor maintenance and repair. These structures carry people, school buses, agricultural products, ranching products, oil field equipment and other uses, and should be designed conservatively. The designer should be aware of extreme events that could occur and take reasonable cost effective measures so the structures would suffer little or no damage.

B. BRIDGE WIDTHS

Bridge width consideration should take into account the approach roadway width, agricultural equipment use, special truck use, and the functional classification. Future ADTs should be used for bridge and approach roadway designs.

C. HYDRAULICS

A hydraulic report should be written and submitted to the bridge owner and the reviewing agency. Minimum design Qs for passing flows without roadway overtopping for different road classifications:

- Q10 for local roads
- Q10 for Minor Collectors
- Q25 for Major Collectors

If the approach roadway has a fuse plug the design Q will be the Q when flow goes over the fuse plug.

Q calculation methods


2. SCS Method for 200 acres < drainage area < 640 acres; see “NEH-Part 630-Hydrology” for SCS Method. (NEH = National Engineering Handbook and Part
630 is the hydrology section. Link to NEH manual: http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/technical/alphabetical/water/hydrology/?&cid=stelprdb1043063


Fuse plugs
Fuse plugs should be incorporated in approach roadway where possible. If a fuse plug cannot be constructed, the design Q will be the minimum Q that passes under the bridge with freeboard.

Freeboard
Freeboard is the height of the bottom chord above the water surface at the design Q. Freeboard shall be a minimum of 1 foot or as required by the local floodplains management policies.

Velocities
1. Flows under a span bridge should not exceed 8 ft/sec. over natural channel bottom.
2. Flows through an RCB barrel with a concrete bottom shall not exceed 15 ft/sec. The flow rate past the concrete floor of the apron area shall not exceed 12 ft/sec. and shall be slower if scour could be a problem. If velocities through the RCB exceed 2 ft/sec, then minimum 4’ curtain walls and aprons or other scour acceptable protection measures are required. Flows through an RCB with natural channel bottom shall not exceed 8 ft/sec.

Backwater
1. Backwater should not exceed 1-foot elevation over the flow elevation in the natural channel without a bridge or without any other encroachments on the stream.
2. Headwater at a culvert shall not exceed 1.2 times the height of culvert opening.

D. HORIZONTAL ALIGNMENT

Curves
Curves on bridges should be avoided if at all possible. Do not construct a curve at each end of a bridge with the bridge being on a tangent. Use good engineering judgment for bridge alignment.
Superelevation

The bridge and roadway should be designed such that the horizontal and vertical alignment smoothly transitions vehicles from roadway to the bridge and back to the roadway adjusting tangents, curves, and superelevations as needed.

Superelevation on bridges is not recommended, however if necessary, then the superelevation should be held constant for the full length of the bridge. Preference for constructability is that superelevation across a bridge should not exceed 2%; the maximum allowed is 6%. Use sound engineering judgment when constructing superelevation on bridges.

E. VERTICAL ALIGNMENT

Roadway traffic velocities for sag and crest curves shall govern vertical alignment. Crest curves should be sufficiently flat for the driver to see the end of the bridge from the beginning of the bridge.

Haunches

1. Bridges should have no more than 4” haunch between deck and beam.
2. Haunches should be calculated to allow for dead load deflections.

Alignments that force the beams to be constructed on a grade steeper than 1% shall have beveled anchor plates whose bevel angle is the same as the beam slope and the anchor plate thickness at the center line of the bearing shall be 1 ½”. The maximum preferred beam slope is 6%.

F. BRIDGE SKEWS

Reinforced Concrete Boxes, RCB

Both skewed and non-skewed RCBs may be rotated at any angle as needed to align with the creek channel.

Span Bridges

County span bridges typically have 0 degree skew or 30 degree skew but can be any skew up to 45 degrees. Bridges should not exceed a 45 degree skew.

Use good engineering judgment when requiring a skewed bridge.

G. ROADSIDE SAFETY

Guardrail end units that attach to the bridge barrier rail shall meet guidelines in Chapter 8, Section B. Use reflector units at bridge rail ends. If deviations from these guidelines
are necessary use good engineering judgment when designing end units for bridge barrier railing.

H. LOADS

The minimum design load shall meet the Load and Resistance Factor Design, LRFD, of HL-93 for projects funded with County Improvements for Roads and Bridges (CIRB funds), federal funds or projects with the potential of federal funding. Design analysis of bridges shall follow the ODOT adopted version with revisions of the AASHTO LRFD Design Specifications.

For locally funded “County Built” projects the minimum design standards require a minimum 23-ton operating load rating (H-23).

Heavier design loads may be required by site conditions such as nearby industry with heavy haul trucks such as agriculture, logging and mining. Use sound engineering judgment to justify designing for a lesser load.

I. FOUNDATIONS

Bridge foundations shall be placed on bedrock or in overburden material with a friction resistance of at least 2 times maximum possible load. Deep foundations must be at least 12 feet below the existing streambed and potential scour depths.

Typical foundation types to consider are:
1. Drilled shafts (min depth into rock is two times the shaft diameter.)
2. Pile bents
3. Spread footings
4. Pile footings (Use a minimum pile length of 15 feet. Pilot holes shall be used if piles cannot be driven to the 15-foot minimum.)

Soundings

Soundings should be made at each abutment and for at least one half the number of piers. Soundings taken at each pier is preferable. If soundings were not taken at each pier and the top of rock differs by more than 10 feet between adjacent soundings, then additional soundings shall be taken such that soundings are taken at each pier and both abutments. A qualified geotechnical company familiar with the geology of the area should determine allowable foundation pressures.

See Chapter 14 for additional information.
J. ABNORMAL CONDITIONS

In areas where abnormal conditions exist or conditions that do not fit these preconceived conditions the engineer shall use sound engineering judgment and be able to justify their decisions when deviating from these guidelines.
CHAPTER 13
SPECIFICATIONS FOR THE GEOTECHNICAL INVESTIGATION
FOR ROADWAY DESIGN

A. GENERAL INFORMATION

These specifications provide the procedures for obtaining the geotechnical information, for county road design and construction. These specifications include the general guidelines for conducting geotechnical investigations and are governed by the “Geotechnical Engineering Circular No. 5 - Evaluation of Soil and Rock Properties”, FHWA-IF-02-034, April 2002, the most current AASHTO and ASTM test procedures, and AASHTO R-10.

Geotechnical information is obtained through subsurface investigations, field tests, and the corresponding laboratory tests conducted on samples obtained in the field. The Geotechnical Engineer provides direction and oversight of these operations with day-to-day coordination through the project geotechnical specialist.

A Geotechnical Engineer is a registered professional engineer with geotechnical expertise. A geotechnical specialist is a civil engineer, geologist, engineering geologist, or a trained, experienced, qualified individual that has been certified by the ODOT Materials Division or other approved designated authority.

The Geotechnical Engineer is required to submit a boring, sampling, and testing plan to the Design Engineer for approval prior to beginning the subsurface exploration in order to resolve all matters with regard to sampling, testing and analysis of data.

In conducting geotechnical investigations, the Geotechnical Engineer is responsible for and will be compensated for the following items of work:

- Securing right-of-way
- Filing and obtaining U.S. Army Corps of Engineers Wetland Permits.
- Locating and marking utility crossings, with OKIE, where borings, test pits, or trenches are required in the geotechnical investigation.
- Planning and arranging for traffic control when required in conducting the geotechnical investigation. Traffic control is to be subcontracted outside of ODOT and is required to meet the most current Manual on Uniform Traffic Control Device Specifications during the geotechnical investigation.
- Provide the required location of all test borings and pavement core locations conducted in the preliminary soil surveys, detailed soil investigations and geological investigations. The survey shall be referenced to plan station and offset from the centerline of survey, construction reference line (CRL) or base line given on the project plans. If the project is a new alignment that is beyond the reasonable reach
by a measuring tape of 100 ft. from a reference line, then a supplemental survey contract may be approved.

- Dozer services required for access to test boring locations.
- Borehole closing when applicable.

B. SCOPE

The geotechnical investigation shall consist of performing all or parts of the following surveys and investigations required by the Design Engineer.

**Preliminary Soil Surveys**

1. **Pedological and Geological Survey:** A Pedological and Geological Survey is required for new alignments, new construction requiring a raising of the grade on and above existing alignments. A Pedological Soils Survey is reliant on knowledge of the soil series mapping units and the corresponding taxonomic classification system established by the Natural Resources Conservation Service (NRCS). More detailed information about Pedological Soil Surveys and the NRCS Soil Classification System are provided in Appendix 1 at [http://www.okladot.state.ok.us/roadway/Rdy-pavement.htm](http://www.okladot.state.ok.us/roadway/Rdy-pavement.htm). The general procedures for conducting the Pedological activities are presented below in option A and option B as directed. This includes the procedures for sampling and testing.

**Option A**

a. The pedological survey requires plotting the Center Reference Line (CRL) or the Centerline (CL) for the proposed highway alignment on the appropriate U.S. Department of Agriculture Soil Conservation (SCS) county soil survey report map sheet(s). The map units are delineated on aerial photographs that comprise the aforementioned sheets. They are usually scaled at 1:20,000 and occasionally 1:24,000; either is acceptable. The plotting procedure is also used to establish the length of each soil series map unit (soil phase) as the alignment crosses the map unit delineation. These lengths or distances are to be summed and provided in the report. The CRL and CL locations are taken from the project plans. In the case of soil series complexes, as map units, e.g. Niotaze-Darnell, each series is to be located and treated separately. The type and degree of assistance, as well as the names of the NRCS, or other soils scientist(s) personnel rendering assistance, shall be documented and referenced in detail.

b. Take adequate sample quantities at the site of each soil series to ensure proper testing of each soil horizon as well the composite bulk sample(s). Pits
are acceptable and may be a preferred method. These are to be made along the CRL or CL or referenced to them. If the map unit repeats within the alignment, it need not be resampled, if the series is confirmed by boring to be the same.

c. A composite bulk sample is defined as a mixture of the total depths (thicknesses) of each of the B and C horizons. For example, if a soil series description lists the B horizons as Bt1, Bt2, Btk, Bt3, and B/C, these together will constitute one composite “B” bulk sample. Subsequently, the C/B and C horizons will constitute a second bulk sample “C”, for soil series that contain those particular horizons. In the event that the map unit does not have a B horizon but has an A/C horizon instead, the composite bulk sample shall be taken of the total depth of horizons listed below the A horizon e.g. the A/C or B/C horizon. It is important that the bulk sample be a well blended mixture of soils that are representative of all the respective horizons in the composite sample. In most cases, soil map unit revisions and recorrelations have probably been made to at least a few of the map units encountered along the CRL. This new information is available at the local NRCS field offices, usually located in the county seat or the NRCS State Soil Scientist in Stillwater OK. The NRCS Web Soil Survey is also a good source for county soils maps and information, http://websoilsurvey.nrcs.usda.gov/app/. Copies of all official soils series descriptions, including the new recorrelated series are required for inclusion in the Pedological report.

d. Use the soil map unit with its associated current official soil series description and classification as a guide for sampling and other engineering interpretations. For example, the official description of Kirkland clay loam, 0 – 1% slope; Fine mixed, superactive, thermic Udertic Paleustoll, 6/99, is to be used as a guide for sampling. The Fine mixed, superactive, thermic, Udertic Paleustaoll is the soil series taxonomic description. It consists of the order, suborder, great group, subgroup modifier, particle size, mineralogy, and soil temperature. In this description the typical thickness of the A horizon is 8 inches, the Bt1 horizon is typically 8 to 19 inches thick, the 2Bt3 is 75 to 82 inches thick, etc. In the map unit of interest, the depths and thickness of the subhorizons may vary from that of the description given in the county soil survey report and/or in the official soil series description. However, they must be within the “Range in Characteristics,” as described in the official soil series description (OSD). A Soil Taxonomy Statement is required for each soil series consisting of a written interpretation of each taxonomy description sub-part for a total of seven parts. Guidelines for preparing the Soil Taxonomy Statement are included in Appendix 1 at http://www.okladot.state.ok.us/roadway/Rdy-pavement.htm.
e. There may be inclusions of a contrasting or similar soil series within the map unit being sampled. They may be listed and described in the “Competing Series” or the “Geographically Associated Soils” paragraphs in the official soil series descriptions. Select the best-fit soil series description from this list, if possible, for the inclusion in the report.

f. Laboratory tests required for all representative subhorizon samples for each soil series are as follows:

1. Plastic Limit, AASHTO T90
2. Liquid Limit, AASHTO T89
3. Gradation required for complete soil classification, AASHTO T88
4. pH, AASHTO T289
5. Electrical Resistivity, AASHTO T288
6. Soluble Sulfates, for projects in ODOT Field Divisions 4, 5, 6, & 7, OHD L-49

g. Laboratory tests required for the bulk composite sample for the B and C horizons of each soil series are as follows:

1. Plastic Limit, AASHTO T90
2. Liquid Limit, AASHTO T89
3. Gradation required for complete soil classification, AASHTO T88
4. Moisture-Density, AASHTO T99 – (include a minimum of 5 points)
5. Resilient Modulus, AASHTO T307
6. Soluble Sulfates, for projects in ODOT Field Divisions 4, 5, 6, & 7, OHD L-49

h. The geologic portion of this survey shall consist of the inclusion of a representative sample of the R horizon. A geologic statement describing the R horizon in geological terminology shall be included in the report. If the R horizon is shale it shall be sampled and subjected to the soil laboratory tests listed under paragraph “f” above. The terminology for describing the R horizon material shall be taken from the “Standard Guide for the Description of Surface and Subsurface Geological Rock Formations of Oklahoma” found in Appendix 3 at http://www.okladot.state.ok.us/roadway/Rdy-pavement.htm.

i. The quantities of soil required for the tests are provided in AASHTO R-13.

j. Personnel requirements. The person performing the pedological soil survey and providing the report shall hold a Bachelor of Science (BS) degree in Soil Science or Civil Engineering. The person may hold a BS in a natural science
(i.e. geology or forestry) provided the natural science has a minimum of 30 credit hours of natural sciences with 15 of those hours in soil science. Alternatively, a resume of pertinent education and experience shall be submitted to the Geotechnical Engineer of the Oklahoma Department of Transportation for review and approval.

Option B

The CRL or centerline of the proposed project is to be plotted on the soil survey map as in Option A. The soil series are to be organized by the Soil Taxonomy Order. The most predominant soil series (largest lineal extent) for each Order in the project extent is to be sampled and tested as required in Option A.

2. Shoulder Soil Survey: A Shoulder Soil Survey is required for the widening of existing pavement at grade. This survey shall apply to the adding of shoulders, and widening existing roadways. The general procedure for conducting the shoulder soil survey is as follows:

a. The sampling location shall be within the station extents of the widening section using the average width of the improvement and a sampling interval of 500 feet. Sample locations shall apply to all widening extents as detailed in the project plans, i.e., outside pavement shoulder.

b. The sampling depth shall be 36 inches consisting of the top 6 inches and the bottom 30 inches provided that there is a reasonable consistency and similarity of material. If different material is encountered in the bottom 30 inches, subdivide the layers and include a sample from each layer.

c. Report the extent(s) of similar soil classifications within the station extents of the project.

d. Record the depth of groundwater or perched water zones measured from the top of ground elevation at the end of drilling.

e. A composite bulk sample(s) of the full sampling depth representative of the whole project extent or of each different soil extent as identified in item 2c.

f. Laboratory tests required of all sample interval depths and/or soil layers are as follows:
   1. Plastic Limit, AASHTO T90
   2. Liquid Limit, AASHTO T89
   3. Gradation required for complete soil classification, AASHTO T88
4. Moisture-density, AASHTO T99
5. Resilient modulus, AASHTO T307
6. Soluble Sulfates, for projects in ODOT Field Divisions 4,5,6, &7, OHD L-49

g. Guidelines for quantities of soil samples are given in AASHTO R13

3. **In Place Soil Survey**: The In Place Soil Survey may be used to evaluate the subgrade of existing pavement sections, which are to be reconstructed with no change in grade or alignment. The general procedure for conducting the In Place Soil Survey is the same as for the Shoulder Soil Survey with the following exceptions:

   a. The sampling interval for grading projects is 1000 ft. or wherever there is a visual change in soil types. Sampling locations for existing pavement sections will most likely be project specific such as at a bridge approaches and underpasses.

   b. The sampling depth shall be 36 inches unless otherwise noted. Sample and test the different soil types encountered in the boring and record the extent(s) of similar soil classifications within the station extents of the project.

4. **Pavement and Subgrade Soil Survey**: A Pavement and Subgrade Soil Survey is required when the properties of an existing pavement structure and the underlying subgrade soils are needed for evaluation of the pavement load capacity and for an overlay design. At the discretion of the engineer the Falling Weight Deflectometer (FWD) may be required for evaluating the pavement structure (surface, base, and subbase). The general procedure for conducting pavement deflection tests shall meet all requirements of the ASTM D4694 and D4695 with the following additional requirements:

   a. FWD tests are to be conducted in the outside wheel path in a staggered pattern at a spacing of 250 feet along the highway centerline. Additional requirements for the FWD analysis are as follows:

      1. The FWD is to be operated during a time frame of April through November or when the ambient temperature has been a minimum of 45 degrees for 3 successive days prior to and during the testing operations.

      2. The air and pavement temperatures are to be recorded by the FWD equipment for each test location and according to ASTM D4695, Subsection 7.1.5.
3. At each FWD test location, the test procedure shall be according to ASTM D4694, Subsection 9. Load and deflection sensors are to be in current calibration at the time of testing, as required by ASTM D4694, Subsection 8. Deflection testing shall include 2 seating drops and 4 recording drops per test location. Local and County roads will be tested with a 7,500 lb. load.

b. Back calculation analysis of the pavement section shall be made using the most current edition of the Modulus program. For asphalt pavement sections, provide the back-calculated resilient modulus of the subgrade and the elastic modulus of the composite pavement structure. For concrete pavement sections, provide the modulus of subgrade reaction, the pavement section thickness, and the pavement condition as determined according to the survey described in item 5d. A copy of the FWD report shall be submitted, in Microsoft Excel Format, electronically to the Design Engineer.

c. A minimum of five pavement cores per mile (more if there is an obvious change in pavement structure) shall be taken to document the thicknesses, types, and condition of the payment layers. Take the cores at FWD test locations. Provide a digital, color photograph of each core with scale. Record the layer thicknesses and the degree of stripping or deterioration of asphalt pavement cores. Record honeycomb, deterioration cracking (D-Cracking), and separations in concrete pavements. Examples of the required core logs are provided in Appendix 5 at http://www.okladot.state.ok.us/roadway/Rdy-pavement.htm. Cores shall be taken in the middle of the slab in PCC Pavements. Ground Penetrating Radar may be used to reduce the number of cores taken to accurately determine the pavement section profile.

d. Pavement surface condition shall be described according to the distress patterns as detailed in the FHWA publication No. FHWA-RD-03-031 “Distress Identification Manual for the Long Term Pavement Performance Program”.

e. For plain jointed, rigid pavements, joint efficiency shall be tested in each direction, in the right wheel path of the right lane, every 600 feet (180m) at the transverse contraction joint. A core shall be cut through the joint at the test site and the core condition reported.

f. The pavement subgrade shall be sampled to a depth of 36 inches below existing pavement. Dynamic Cone Penetration tests, DCPT, may be requested to further evaluate the strength and consistency of the subgrade.
g. Report the extent(s) of similar subgrade soils within the station extents of the project.

h. Record the depth of groundwater or perched water zones measured from the top of ground elevation at the end of drilling.

i. Laboratory tests required of granular bases, subbases, and subgrade soils are as follows:
   1. Plastic Limit, AASHTO T90
   2. Liquid Limit, AASHTO T89
   3. Gradation required for complete soil classification, AASHTO T88

j. Guidelines for quantities of soil samples are given in AASHTO R13.

5. **Borrow Pit Investigation:** A borrow pit investigation is required where selective subgrade topping is requested. The specifications for selective subgrade topping are provided in the most current issue of the ODOT Standard Specifications for Highway Construction, Section 202.02 B.

   a. The size of the borrow pit shall be based on plan estimates of borrow quantities needed.

   b. A borrow pit location within a 30-mile haul distance of the project is acceptable.

   c. As a minimum requirement, a boring shall be drilled at each geometric corner and two near the center. A minimum depth of ten feet per boring shall be analyzed for select material.

   d. Record the depth of groundwater or perched water zones measured from the top of the ground elevation at the end of drilling.

   e. If the borrow source is rock, investigate the rippability by use of seismic velocity. Refer to the seismic velocity charts found in the Appendix 3 at http://www.okladot.state.ok.us/roadway/Rdy-pavement.htm to estimate the rippability of rock.

   f. If the borrow sources can be select graded in a cut section of the proposed project site, the above items c. through e. all apply.
g. If a borrow source is unavailable, then a pavement layer requiring borrow may be substituted with an equivalent layer of chemically stabilized soil or a soil-aggregate blend.

h. Soils that are to be placed within the top 2 ft. of the grading section shall be tested for soluble sulfates according to OHD L-49.

i. Laboratory tests required of borrow pit soil samples are as follows:
   1. Plastic Limit, AASHTO T90
   2. Liquid Limit, AASHTO T89
   3. Gradation required for complete soil classification, AASHTO T88
   4. Soluble Sulfates, for projects in ODOT Field Divisions 4,5,6, &7, OHD L-49

6. **Resilient Modulus Tests:** Resilient modulus testing is required for the pavement design of all State and Federal Aid highway projects. This test is conducted, according to the requirements of AASHTO T-307, on composite bulk samples obtained in Pedological, Shoulder, and In Place Soil Surveys. A qualified technician having a minimum of 2 years continuous experience in resilient modulus testing shall conduct resilient Modulus testing for ODOT.

   ODOT requires two resilient modulus tests for each composite sample:
   - One test at 95 % of maximum dry density, optimum moisture content
   - One test at 95 % of maximum dry density, 2 % wet of optimum moisture content.

7. **Laboratory Tests:** All laboratory tests required for the Preliminary Soil Surveys shall be performed by technicians certified by the Highway Construction Materials Certification Board in a laboratory qualified by the ODOT Materials Division.

C. DETAILED SOIL INVESTIGATION

If needed, a detailed Soil Investigation is required for analyzing the geotechnical problems related to roadway designs. These geotechnical problems include embankment and foundation soil settlement and stability, cut and natural slope stability, problem soils related to roadway subgrades and embankments, roadway structures, and construction recommendations. A detailed soil investigation of these problems is required in conjunction with the Pedological and Geological Survey. The interpretation and judgment of the pedological and geological site conditions is the responsibility of the Geotechnical Engineer.

1. **Embankment and Foundation Soil Settlement and Stability (Embankments Between 0-10 feet Above Natural Ground Line):** Estimates of embankment and
underlying foundation soil settlement, slope stability and design slopes are required. Assuming reasonable parameters for anticipated embankment makes these estimates and foundation soils based on the soil series types occurring within the project extent. These estimates are required for embankments crossing each soil series encountered along the project alignment. Use NAVFAC D 7.01 to determine estimates of reasonable soil parameters for anticipated embankment and foundation soils as described by the pedological soil units.

2. **Embankment and Foundation Soil Settlement and Stability (Embankments Greater Than 10 Feet Above Natural Ground Line):** Estimates of embankment and underlying foundation soil settlement and stability may be required by the Design Engineer. Borings are to be typically spaced every 200 feet (erratic conditions) to 500 feet (uniform conditions), with at least one boring made in each Pedological soil unit. The primary borings are to be Standard Penetration Test (SPT) borings. These borings, which are for obtaining soil samples and information, should be supplemented with in situ field tests such as the Cone Penetration Test (CPT) or the Flat Plate Dilatometer Test (DMT) to obtain additional information for determining the soil and rock subsurface conditions as follows:

   a. **Stratigraphy**
      1) Physical description and extent of each stratum
      2) Thickness and elevation of top and bottom of each stratum

   b. For cohesive soils (each stratum)
      1) Natural moisture contents
      2) Atterberg limits
      3) Presence of organic materials
      4) Evidence of desiccation or previous soil disturbance, shearing or slickensides
      5) Swelling characteristics
      6) Shear strength
      7) Compressibility – **NOTE:** The Standard Penetration Test is not to be used for shear strength or compressibility analysis in cohesive soils. Shear strength and compressibility can be determined by laboratory consolidation tests conducted on undisturbed soil samples or by in situ field tests such as the Cone Penetration Test (CPT) or the Flat Plate Dilatometer Test (DMT).

   c. For granular soils (each stratum)
      1) In-situ density (average and range) typically determined from Standard Penetration Tests (SPT) or Cone Penetration Tests (CPT)
2) Grain-size distribution (gradation)

3) Presence of organic materials

d. Ground water (for each aquifer if more than one is present)

1) Piezometric surface over the site area, existing, past, and probable range in future (observation at several times.)

2) Perched water table

e. Bedrock

1) Depth and elevation over the entire site

2) Type of rock (Lithology)

3) Extent and character of weathering

4) Joints, including distribution, spacing, whether open or closed, and joint filing.

5) Faults

6) Solution features in limestone or other soluble rocks

7) Core recovery and soundness (RQD)

f. Engineering Analysis. The minimum guidelines required for engineering analysis, based upon soil classification, are given in Table 1 of Appendix 2 at http://www.okladot.state.ok.us/roadway/Rdy-pavement.htm. Additional guidelines should be noted for the following conditions:

1) When soft ground is encountered (SPT ‘N’ Resistance < 4), conduct in situ tests and/or undisturbed sample exploration in each soil series mapping unit. Conduct continuous in situ tests and/or undisturbed sampling throughout the foundation soils until firm material (SPT ‘N’ Resistance > 30) or rock is encountered.

2) When medium stiff to very stiff (5 < SPT ‘N’ resistance < 30) is encountered, follow the minimum sampling and testing criteria in Table 2 of Appendix 2 at http://www.okladot.state.ok.us/roadway/Rdy-pavement.htm.

3) If rock is encountered within a depth equal to twice the embankment height, conduct continuous rock coring as detailed in Table 2 of Appendix 2 at http://www.okladot.state.ok.us/roadway/Rdy-pavement.htm.

4) Groundwater investigations shall be made according to Table 2 of Appendix 2 at http://www.okladot.state.ok.us/roadway/Rdy-pavement.htm.
5) For bridge embankment headers, conduct a detailed study of the embankment and foundation soils within 200 feet back and 200 feet forward of each bridge abutment.

3. **Cut and Natural Slope Stability:** Cut slopes greater than 30 feet below the natural ground line in soil shall be analyzed for both end of construction and long term slope stability conditions. If slope materials are overconsolidated (OCR > 2) then the residual shear strength shall be used in the long-term slope stability analysis. Soils coming from cuts that will be placed within the top 2 ft. of the grading section shall be checked for soluble sulfates according to OHD L-49.

4. **Problem Soils Related to Roadway Subgrades and Embankments:** Additional field exploration, laboratory testing and analysis are required to determine the long-term performance and/or suitability of the following soil and rock that may be incorporated into the roadway subgrade and embankment or found in the foundation soils below the roadway embankment:
   a. Organic soils
   b. Normally consolidated clays
   c. Expansive clays and shales
   d. Dispersive soils
   e. Collapsible soils
   f. Degradable shales
   g. Caliche
   h. Mine spoils (all types) and caves
   i. River or stream meander loops and cutoffs and ox-bow lakes
   j. Karst features (e.g., gypsum, limestone)

   These soils and conditions are coordinated with the Pedological and Geological Survey and Borrow Pit Investigation. The interpretation and judgment of these soil conditions is the responsibility of the Geotechnical Engineer.

5. **Roadway Structures:** Check the bearing capacity, settlement and stability of roadway structures (i.e. retaining walls) according to the most current AASHTO Standard Specifications for Highway Bridges.

6. **Construction Recommendations:** The Geotechnical Engineer may recommend chemically stabilized bases, subbases and subgrades as directed by the Design Engineer or in lieu of select borrow requirements of the most current edition of the Oklahoma Department of Transportation (ODOT) Standard Specifications for Highway Construction. These recommendations are limited to lime, fly ash, CKD, and Portland cement and the method of evaluation shall follow ASTM D4609, OHD L-50 and OHD L-51.
D. GEOLOGICAL INVESTIGATION

A Geological Field Investigation may be required for any or all of the following:
1. rock cuts of 10 feet or greater
2. shallow rock mapped within a proposed cut section
3. rock mechanics analysis
4. geological hazards
5. rock fills

A geological field investigation may consist of the following elements:
1. borings
2. slope stability analysis
3. rippability ratings
4. evaluation of geological hazards
5. shear strength of rock fills
6. evaluation of excavated rock for use as a source of aggregate
7. Geological statements.

The Geological Investigation is in conjunction with the Pedological and Geological Survey. Dimensions are to be in English or metric units, whichever is compatible with the Plans. Any interpretations and judgments made of the site geologic conditions are the responsibility of the Geotechnical Engineer. The investigation may include the following:

1. **Borings:** Space borings through cut sections within the project extent every 100 feet in the longitudinal centerline (CL or CRL) direction. Provide a minimum of two borings along a straight line perpendicular to the centerline or planned slope face to establish a geological cross-section of the cut. Two of these borings shall be continuously cored to characterize the soil and/or rock properties. The depths of all borings are to extend a minimum of 10 feet below the deepest plan grade. Record the location of perched or permanent water tables for a minimum of 24 hours.

2. **Seismograph Surveys:** Seismograph Surveys of cut sections may be required. The equipment must be capable of determining rock properties throughout the entire depth of the cut, plus 10 feet below plan grade. Depths to each rock layer must be accurate to the nearest foot.

3. **Rock Stability Analysis:** Rock stability analysis is required when the dip of the geological formation exceeds 20 degrees into the slope face. Ensure the analysis meets all the requirements of the kinematic slope stability program, RockPack III (or equivalent), using the stereographic projection procedure. This analysis is
necessary to determine the slope stability of closely spaced (2 ft. or less) rock joints (fractures) and/or tilted (dipping greater than 10 degrees) rock strata of the cut slope. These measurements will allow development of the local structural geology, in three dimensions, required for making this analysis. The data that is required for this analysis is the dip, and dip direction of both the rock strata and of the joints (fractures) in the rock. The equipment necessary to obtain the dip, and joint orientation data is a Clar and/or Brunton compass. This device gives magnetic headings and dip angles. Trenching or oriented cores may be necessary in order to expose enough rock strata to make the measurements. The shear strength of the jointed rock shall be based on the requirements of the Hoek-Brown (1988) criteria. If the observations identify joints (fractures) in which shear failures may occur, or fractures that contain soil infilling; then, the shear strength of the infilling or fractures is required to be taken into account in the overall slope stability analysis. In argillaceous massive shales (non-laminar), slope stability analysis shall be based on the use of a soil mechanics approach.

4. **Rippability:** Determine rippability by a refraction seismograph. The seismograph must be capable of providing valid, useable signals for calculating the depth to bedrock to nearest foot. It must be capable of sensing rock layers to the depth of the proposed cut. Calculations of rock rippability shall be made from the resulting sound wave velocities. The rock rippability rating of each layer shall be reported as rippable, marginal, or non-rippable.

5. **Geologic Hazards:** Identify any geologic hazards (e.g. sinkholes, landslides, and others). These are to be precisely located and dimensioned to the nearest foot. Record all occurrences in the final report. GPS coordinates may be used in addition to Public Land Survey legal descriptions. Locations must be referenced to the CL or CRL by plan station and offset.

6. **Rock Fill Embankments:** Determine the shear strength values of rock fill embankments. Using the results of the triaxial shear tests will generate the model. Conduct the testing on 1-in. size aggregates from the specified rock fill aggregate source.

7. **Geologic Site Assessment:** Provide a geologic site assessment of the rock type and layering conditions in the cuts along the CL or CRL. This report will be based on available geologic maps, bulletins etc., along with a field, on-site investigation. The assessment will pertain to the geologic conditions and character of the rock strata as provided in the above geologic information sources.
8. **Equipment:** List the equipment used to make the observations (e.g. borings, seismograph surveys, rippability, and stability analysis) in the report. Provide the make, model, and manufacturer.

**Descriptive Terminology and Rock Classification:** The descriptive terminology and rock classification shall be based upon the “Standard Guide for the Description of Surface and Subsurface Geological Rock Formations of Oklahoma” as presented in Appendix 3 at [http://www.okladot.state.ok.us/roadway/Rdy-pavement.htm](http://www.okladot.state.ok.us/roadway/Rdy-pavement.htm). The finished boring log shall be a compilation of all classification and description from laboratory tests and field logging.

E. **GEOTECHNICAL EXPLORATION, IN SITU TEST PROCEDURE**

1. The most current issue of the following ASTM Standards for in situ testing will govern and shall be used.
   a. Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils – ASTM D1586
   b. Electronic Friction Cone and Piezocone Penetration Testing of Soils – ASTM D5778
   c. Mechanical Cone Penetration Test – ASTM D3441
   d. Flat Plate Dilatometer Test – ASTM D 6635
   e. Pressuremeter Test – ASTM D 4719
   f. Vane Shear Test – ASTM D 2573
   g. Dynamic Cone Penetrometer Test – ASTM D 6951

2. The most current issue of the following ASTM and AASHTO Standards for sampling will govern and shall be used.
   a. Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils – ASTM D1586
   b. Practice for Thin-Walled Tube Geotechnical Sampling of Soils – ASTM D1587
   c. Practice for Rock Core Drilling and Sampling of Rock for Site Investigation – ASTM D2113
   d. Practice for Preserving and Transporting Soil Samples – ASTM D4220
   e. Collection and Preservation of Water Samples – AASHTO R24
   f. Standard Test Method for Determining Subsurface Liquid Levels in Borehole or Monitoring Well (Observation Well) – ASTM D4750

3. **Bore Hole Completion and Site Restoration:** All borings should be properly closed at the end of the field exploration for safety considerations and to prevent cross contamination of soil strata and groundwater. The general procedures for borehole completion and site restoration are as follows:
a. **Responsibility**  
The driller is responsible for properly plugging the borehole.

b. **Timetable**  
Ensure borings are plugged within 10 days of completion of drilling or groundwater observations to prevent contamination of groundwater.

c. **Backfill**  
Consider the following:

1. For Pedological, shoulder, and in-place borings, backfill and compact the borehole with borehole cuttings.

2. In pavements, backfill the boreholes with cuttings. Compact, by tamping, the cuttings to a depth of 6 in. below the bottom of the pavement. Fill the remainder of the boring with either quick setting concrete or asphalt patch depending upon the pavement type.

3. For embankment and cut section borings, follow the procedures outlined in **AASHTO R-22**.

d. **Property Cleanup**  
As practical, the site should be returned to its original conditions. For sensitive locations, take before and after photographs to address possible complaints from the landowner.

4. **Field Logging:**  
Field logs shall be based upon the descriptive terminology and classification of rock detailed in the “Standard Guide for The Description of Surface and Subsurface Geological Rock Formations of Oklahoma” as presented in Appendix 3 at [http://www.okladot.state.ok.us/roadway/Rdy-pavement.htm](http://www.okladot.state.ok.us/roadway/Rdy-pavement.htm).

5. **Method of Drilling:**  
An appropriate method of rotary drilling shall be used for the foundation and geologic conditions encountered. These are described in the AASHTO Manual on Subsurface Investigations, 1988. There is no restriction on the type of drill equipment other than it shall be capable of performing all of the field sampling and testing as outlined in the above referenced manual. Samples may be taken from the flight augers unless water table conditions are encountered. The practice of auger refusal is **not** an acceptable technique for defining the top of bedrock. The top of bedrock shall be established by sampler refusal as outlined in **ASTM D 1586 - Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils**. For borings over water in lakes or rivers, drilling operations shall be performed on a barge supported by spud rods firmly anchored at each corner.

6. **Geologic Statement:**  
A general geologic review and assessment(s) shall be provided as a statement in the Geologic Investigation. It will include cross section(s) and provide drawings, showing the orientation of the rock masses or layered rock formations at each cut section investigated. The drawings will provide station designations along the centerline of survey or CRL and offset distances left
and/or right. The geologic summary will be provided based on all available geologic information. Examples of such sources are as follows:

a. Oklahoma Geological Survey
b. Oklahoma Water Resources Board
c. U.S. Geological Survey
d. Tulsa Geological Society, and others

F. LABORATORY TESTS

All laboratory testing shall be performed by technicians certified by the Highway Construction Materials Certification Board in a laboratory qualified by the ODOT Materials Division.

1. Where appropriate, soils and rock samples are to be tested and results reported according to the most current AASHTO/ASTM Standards for the following tests:

   a. Soils Classification, Gradation and Plasticity Index – AASHTO T88, T89, and T90
   b. Moisture Content, AASHTO T265
   c. Specific Gravity, AASHTO T100
   d. Chunk Density, AASHTO T233
   e. Hydrometer, AASHTO T88
   f. Double Hydrometer, ASTM D4221
   g. Pinhole Test, ASTM D4647
   h. pH, AASHTO T289
   i. Moisture-Density Test
      1) Standard, AASHTO T99
      2) Modified, AASHTO T180
   j. Electrical Resistivity, AASHTO T288
   k. Slake Durability, ASTM D4644
   l. Unconfined Compression Test, AASHTO T208
   m. Point Load Test, ASTM D5731
   n. One-Dimensional Consolidation Test, AASHTO T216
   o. Drained Direct Shear Test, AASHTO T236
   p. Triaxial Shear Test
      1) Unconsolidated Undrained, ASTM D2850
      2) Consolidated Undrained, ASTM D4767
   q. Residual shear strength, ASTM D6467
   r. One Dimensional Swell or Settlement Potential of Cohesive Soils, ASTM D456
2. Classification and description of soils and compaction shales follow the practice as outlined in ASTM D2487 and D2488. For classification purposes, define, test, and report for the following particle size distribution.

- 3 in. (75 mm)
- ¾ in. (19 mm)
- No. 4 (4.75 mm)
- No. 10 (2.00 mm)
- No. 40 (425µm)
- No. 200 (75µm)

3. A pocket penetrometer or any other “pocket” measurement device shall not be used to determine rock or soil properties for the purposes of this investigation.

G. FINAL WRITTEN REPORT

The final report shall be written by a Geotechnical Engineer with a broad experience and background in engineering for the type of roadway work identified in the project. All pertinent information to be included in the final report is detailed in:

Appendix 4 – Guidelines For Preparing Geotechnical Reports at http://www.okladot.state.ok.us/roadway/Rdy-pavement.htm.

Appendix 5 at http://www.okladot.state.ok.us/roadway/Rdy-pavement.htm provides the Standard Forms For Reporting Geotechnical Information.
CHAPTER 14
SPECIFICATIONS FOR THE GEOTECHNICAL INVESTIGATION
OF BRIDGES AND RELATED STRUCTURES

A. GENERAL INFORMATION

The current issue of the “AASHTO Manual on Subsurface Investigations” shall govern the general procedure for the execution of investigation for bridges and related structures’ foundations. Unless otherwise noted herein by the following exceptions or amplifications, said investigations shall subscribe to, as a minimum requirement, the general guidelines given in Chapters 1.0 through 10.0 and Appendices A through H of the AASHTO Manual Subsurface Investigations. The Contractor is required to furnish the Design Engineer the proper data on the engineering properties and analysis and design requirements as specified in and according to the most current AASHTO LRFD Design Specifications. These AASHTO specifications are minimum requirements, and the Contractor may exceed them. The Contractor is responsible for providing the Design Engineer with sufficient information as necessary to verify foundation adequacy. In making geotechnical investigations, the Contractor is also responsible for damages that occur to property as a result of those investigations. The contractor is responsible for contacting OKIE and notification of property owners.

B. EXCEPTIONS TO AND AMPLIFICATIONS OF BORING PLAN

At least one boring will be made at each pier or bent and at each of abutments in a staggered pattern for all structures and alternates or as otherwise directed. Additional requirements are noted below.

1. Where substructure units will be supported on deep foundations, the depth of the subsurface exploration shall extend a minimum of 20 feet below the top of rock. Where pile or shaft groups will be used, the subsurface exploration shall extend at least two times the maximum pile group dimension below the anticipated tip elevation, unless the foundations will be end bearing on or in rock. For piles bearing on rock, exclusive of shale, a minimum of 10 feet of rock core shall be obtained at each exploration location to ensure the exploration has not been terminated on a boulder. Minimum of 120 feet if rock or shale is not encountered. Auguring is allowed to refusal.

2. **Sampling Interval:** The maximum sampling interval throughout the boring depth is 5.0 feet in homogeneous strata. In non-homogeneous strata, the sampling interval is less than 5.0 feet with testing and sampling at changes in strata. The standard
penetration test split-barrel sampler will be used in all cases except when soft clays or silts are encountered, in which case thin-wall tube samples may be substituted.

3. **Weathered Rock or Shale:** When weathered rock or shale is encountered, the standard penetration test shall be made at the top of the weathered rock or shale and continue until refusal is met in accordance with current ASTM D 1586 Section 7.1. Thereafter, one of the following is required.

   a. Continuous core barrel sampling according to current ASTM D 2113 (minimum size NWG, NWM) to a total depth of 20 feet and shall be restricted to locations shown on the enclosed map. All core logs shall include the following information as required by ASTM D 5878:
      1) RQD
      2) Spacing of discontinuities
      3) Condition of discontinuities
      4) Groundwater

   b. Pressuremeter test immediately following the refusal of the standard penetration test and 5 foot (1.5m) intervals thereafter to a total depth of 20 feet (9.1m).

   c. Dynamic Cone Penetrometer Test described in Item 12 and under Field Test shall be made at the top of the weather rock or shale following the refusal of the standard penetration test and at 5-foot intervals, or as directed.

4. **Recommended Load Carrying Capacity:** When directed by the Design Engineer, the Contractor shall recommended the load carrying capacity for the rock or shale, including end bearing and side shear (skin resistance) and other foundation analysis as required by procedures outlined in the most current AASHTO Standard Specifications for Highway Bridges including Interims. When directed by Design Engineer to recommend load capacity for LFRD projects identified on the enclosed map, analysis will require the use of the unconfined compressive test and/or point load test on rock core specimens.

5. **Structures Less Than 250 Feet (75m) in Length:** In the alluvium and bedrock, at least one pier and both abutment borings are required to be sampled as indicated in Items 4 and 5, logged, tested in the laboratory by appropriate test procedure, and described according to current ASTM D 2487 and D 2488. At all other borings, the bedrock is to be sampled as indicated in Item 5, logged, and described according to current ASTM D 2487 and D 2488. A recommended load carrying capacity as required in Item 6 shall be based on at least two pier location borings.
6. **Structures Between 250 and 600 Feet (75m and 180m) in Length:** In the Alluvium and bedrock, at least two pier and both abutment borings are required to be sampled as indicated in Items 4 and 5, logged, tested in the laboratory by appropriate test procedure and described according to current ASTM D 2487 and D 2487. At all other borings, the bedrock is to be sampled as indicated in Item 5 and logged and described according to current ASTM D 2487 and D 2488. Recommended load carrying capacity as required in Item 6 shall be based on all pier location borings; except in the case of a three-span bridge, the carrying capacity will based on two-pier location borings.

7. **Structures Greater Than 600 Feet (180m) in Length:** In the alluvium and bedrock, at least three pier and both abutment borings are required to be sampled as indicated in Items 4 and 5, logged, tested in the laboratory by appropriate test procedure, and described according to current ASTM D 2487 and D 2488. At all other borings, the bedrock is to be sampled as indicated in Item 5 and logged according to current ASTM D 2487 and D 2488. In addition to Item 13 requirements, for depth to top of rock greater than 60 feet, at least one boring shall be sampled continuously by the Standard Penetration Test (SPT) and logged, tested and described according to current ASTM D 2487 and D 2488 and/or static cone penetration test (CPT) methods for the full depth of the boring. For structures in excess of 1500 feet, borings may be spaced at 100 foot intervals in a staggered pattern.

8. **Borings In Bodies of Water:** For borings in bodies of water (i.e., lakes, rivers and streams), all underlying soil material shall be sampled continuously by the Standard Penetration Test, according to current ASTM D 1586 procedure, until weathered rock or shale encountered, and thereafter sampling shall be according to Items 5a, 5b and 5c requirements. In the case of when soft clays or silts are encountered above weathered rock shale, thin-walled tube samples may be substituted.

9. **Dynamic Cone Penetrometer Test:** If the dynamic cone penetrometer test is used to determine the load carrying capacity required in Item 6, then a minimum of five (5) consecutive cone tests having a penetration resistances of two consecutive cone tests having a penetration resistance of two consecutive 50 blows per 6 inch are required at 5 foot intervals.

10. **Rock Depths Greater Than 60 Feet:** For depths to top of rock greater than sixty (60) feet in cohesive and/or granular materials, an estimate of point and skin resistance for friction piles or drilled shafts by static analysis of the various layers shall be made by the Standard Penetration Tests (SPT) and/or Cone Penetration Test (CPT) methods for the full depth of boring. This requirement shall be in addition to Item 5 requirements when the rock depth is greater than 60 feet.
11. **Scour Depth:** For scour depth estimates, the mean $D_{50}$ (mean diameter of the bed material) in granular alluvium is required. Gradation samples shall be tested as described by ASTM D2487 on all samples taken according to the 5 foot intervals in Item 4 in granular alluvium. The depth of weather rock or shale described in item 5 is required. In rock or shale sampled by continuous core barrel, fracture spacing shall be plotted per foot depth for all core runs. The following criteria are required at pier locations.
   a. One Boring for structures less than 250 feet in length.
   b. Two borings for structures between 250 and 600 feet in length.
   c. Three borings for structures greater than 600 feet in length.

12. **Water Table and Watering Sampling:** The water table shall be measured at the end of drilling, recommend 24 hours in all boreholes as specified in the most current ASTM D4750 and at the discretion of the engineer. The Contractor will confirm and monitor the presence of artesian water. For county bridge structures the engineer may require, especially located in ODOT Divisions 5 and 6 (CED 7 and 8), water samples shall be taken from surface pools and from at least one boring at a depth of 10 feet below the water table. Also, water samples are required as indicated above when boring logs indicate a shale or sandstone interbedded with gypsum.

13. **Bridge Approach Embankment Settlement and Slope Stability:** For embankment heights that are greater than 15 feet, settlement and slope stability predictions shall be made according to the requirements of the Specifications for Geotechnical Investigations for Roadway Design.

C. **FIELD RECONNAISSANCE AND C TOLERANCE**

1. Observe and report the following site conditions in reference to the geotechnical investigation of the structure:
   a. Surface soil types.
   b. Gullies, excavations, slopes or stream banks.
   c. Surface and subsurface water.
   d. Topography and vegetation.
   e. Study of existing structures.
   f. Usual drilling conditions.
   g. Underground and overhead utilities
   h. Permission of property owners.
   i. Stream debris.

2. Deviations from the boring location plan, indicated above, due to inaccessible conditions when approved by the Design Engineer.
3. Vertical control of all borings shall be plus or minus (±) 0.10 foot, as documented by survey notes. Elevations shall be taken with an engineer’s level (i.e. Wye Level or higher equivalent).

4. The tolerance in hole location shall be plus or minus (±) 1.0 foot, by taping or chaining.

D. METHOD OF DRILLING

An appropriate method of rotary drilling shall be used for the foundation and geologic conditions encountered as specified in the AASHTO Manual on Subsurface Investigations, 1988. Drilling with continuous flight augers is prohibited. There are no other restrictions on the type of drill equipment, other than that it shall be capable of performing all of the field sampling and testing outlined in the AASHTO Manual on subsurface Investigations, 1988. For borings over water in lakes or rivers, drilling operations shall be performed on barge corners, which are anchored firmly into underlying sediment.

**Sampling:** The most current issue of the following ASTM and AASHTO Standard will govern and shall be used.

1. ASTM D1586, Method for Penetration Test and Split Barrel Sampling of Soils.
2. ASTM D1587, Practice for Thin-Walled Tube Sampling of Soils.
3. ASTM D2113, Practice for Diamond Core Drilling for Site Investigation
4. ASTM D4220, Practice for Preserving and Transporting Soil Samples.
5. AASHTO T264, Collection and Preservation of Water Samples.

E. FIELD TESTS

The most current issue of the following ASTM Standards will govern and shall be used.

1. Standard Penetration Test (SPT) – ASTM D1586. Partial increments of the standard penetration test should be measured to the nearest 1/16 of an inch.


4. Dynamic Cone Penetrometer Test – This test is adopted by the Oklahoma Department of Transportation and described generally in subsection B.4.2 of the
AASHTO Manual on Subsurface Investigations, 1988. The Dynamic cone Penetrometer test used by the Oklahoma Department of Transportation is known as the Texas Cone Penetrometer Test. Deviations from the AASHTO Manual or Subsurface Investigations, 1988, are as follows: 10 Blows to seat the cone and the penetration in inches per 50 blows for the first and second 50 blows; if 6 inches of penetration is obtained before 50 blows, then the number of blows per 6 inches shall be recorded for a total of 12 inches. The physical dimensions and copy of the test procedure shall be furnished by the Oklahoma Department of Transportation. Hammers furnished equivalent energy to a 170-pound hammer with a 24” drop will be acceptable. The dynamic cone penetration should be reported to the nearest 1/16 of an inch.

5. Field Permeability Tests – The requirement is identified in the AASHTO Manual on Subsurface Investigations subsection B.63 as either a falling-head, constant-head, or rising-head test further referenced to Hvorslev (1951).

F. LABORATORY TESTS

Laboratory testing shall be performed by technicians certified by the Highway Construction Materials Certification Board in a laboratory qualified by the ODOT Materials Division. For all samples taken, the following shall apply:

1. All soil and rock samples are to be tested in the laboratory and results reported according to the most current ASTM Standards for the following tests:

   a. Soil Classification (Gradation and Plasticity Index)
   b. Moisture Content
   c. Specific Gravity
   d. Chunk Density (AASHTO procedure only)
   e. Hydrometer, Double Hydrometer Pinhole Test
   f. Slake Durability
   g. Unconfined Compression Test, see (m)
   h. Point Load Test, see (m)
   i. One-Dimensional Consolidation Test
   j. Drained Direct Shear Test
   k. Triaxial Sheer Test
   l. Percent Swell and Swell Pressure Test
   m. Unconfined compression tests on rock core specimens shall include elastic moduli testing also. Unconfined compression tests are to be conducted at an interval not exceeding 5 feet starting at the top of rock. If samples do not
meet the requirements for unconfined compression test, two point load tests may be substituted for each unconfined test at the specific interval.

2. Water samples are to be taken at a minimum of 10-foot intervals with a positive sealing sampler in at least two bore holes. Water levels shall be allowed to reach an equilibrium condition before sampling. Borings advanced by mud (bentonite) rotary drilling technique shall be bailed before allowing water level to reach an equilibrium condition. Where needed, casing must be installed. Samples are to be analyzed for:
   a. CL ion (ppm) by AASHTO T260 (Alternate Method Number 1- Potentiometric Titration)
   b. SO₄ ion (ppm) by AASHTO T105, ASTM C114
   c. pH by ASTM G51

3. Classification and description of soils and compaction shales shall follow ASTM D2487 and D2488. For clarification purposes, define and test for the following particle size distribution:
   - 3 in. (75 mm)
   - ¾ in. (19 mm)
   - No. 4 (4.75 mm)
   - No. 10 (2.00 mm)
   - No. 40 (425 µm)
   - No. 200 (75 µm)

4. A pocket penetrometer or any other “pocket” measurement shall not be used to determine rock or soil properties for the purposes of this investigation.

5. Soil tests required for anchored retaining wall anchor environments are:
   a. Electrical resistivity, ASTM G57, AASHTO T289 Sample Preparation
   b. pH, ASTM D4972
   c. Sulfate, ASTM D516

G. FIELD LOGGING

Descriptive terminology and classification of rock shall be based on the requirements of subsection E.6 in the AASHTO Manual on Subsurface Investigations, 1988 as well as ODOT’s local practice presented in attachment 1. The finished boring log shall be a completion of all classification and description from laboratory tests and field logging.
H. GEOLOGIC STATEMENT

A general review and assessment of specific site geology shall be reported based on all available soil surveys and geologic bulletin maps for the location. All sources shall be documented.

I. MINIMUM PLUGGING REQUIREMENTS FOR GEOTECHNICAL BORINGS

The general procedure for the plugging of Geotechnical Borings shall be governed by the current Oklahoma Water Resources Board specifications “Plugging Requirements for Geotechnical Borings”. Unless otherwise noted herein by the following exceptions or amplifications, and procedures shall subscribe to, as a minimum requirement, the general guidelines given in 785:35-11-1 and 11-2 of the Oklahoma Water Resource Board’s Regulations.

Exceptions and Amplifications to the above are as follows:

1. Responsibility for proper plugging lies with the contractor.

2. Borings shall be plugged to prevent pollution of groundwater within ten (10) days of completion of drilling.

3. A multi-purpose completion report shall be submitted to the Oklahoma Water Resources Board within thirty (30) days of completion and plugging of each geotechnical boring and to the Oklahoma Department of Transportation in the Final Written Report.

4. Guidelines for borehole plugging, grouting procedures, grout mixes, etc., are explicitly detailed in the Oklahoma Water Resources Board’s Specifications.

K. FINAL WRITTEN REPORT

In addition to the graphical and tabular data, a written report shall also be made. It shall contain an interpretation and analysis of the data as well as definite engineering recommendations for design based upon the various factors. The geotechnical report shall be thorough in reporting all backup data and calculations documenting analysis and recommendations in accompanying appendices to the report. The materials and conditions, which may be countered during construction, shall be discussed. The Geotechnical Engineer responsible for the report preparation should have a broad enough background in engineering to have some knowledge of the type of the structures, which normally would be used, in a certain location, including their foundations requirements and limitations. The Engineer should anticipate as many
problems of design and construction as possible, and make recommendations for their solution. The recommendations should be brief, concise and, where possible, definite. Reasons for recommendations and their supporting data should always be included. Extraneous data, which are of no use to the designer or Resident Engineer, should be omitted. The units in the analyses and final report shall be consistent with plan requirements. Final written report may require computer generated boring logs as directed. The written report should include the following specific items.

1. Pile Support
   a. Method of support: Friction or end bearing, in rock or soil or both
   b. Suitable pile type or type or types: Reasons for choice and/or exclusion of types
   c. Pile tip elevations:
      1) Estimated – Average values, with range of various if desirable
      2) Specified – Explain reasons, such as driving through fill, negative skin friction, scour, underlying soft layers, piles and uneconomically long, etc.
   d. Allowable pile loading: Specify method of analysis
   e. Settlement considerations: Requirements of structure vs. soil conditions. Specify method of analysis
   f. Cut-off elevations: Water table, etc.
   g. Test piles required: Location for maximum utility
   h. Load tests required and use of dynamic pile driving formula
   i. Effects on adjacent construction
   j. Corrosion effective of various soils and waters, and possibility of galvanic reaction
   k. Scour depth knowledge
   l. P-Y curve analysis

2. Drilled Shaft Support
   a. Method of support: Friction or end bearing, in rock or soil or both
   b. Suitable drilled shaft size: Reasons for choice and/or exclusion of sizes
   c. Drilled shaft base elevations
   d. Allowable drilled shaft loading: Specify method of analysis
   e. Settlement considerations: Requirements of structure vs. soil conditions. Specify method of analysis
   f. Cut-off elevations: Water table, etc.
   g. Drilled shafts required: Locations for maximum utility
   h. Corrosion effects of various soils and waters
   i. Scour depth knowledge
   j. P-Y curve analysis
3. **Footing Foundation Support**
   a. Elevation of footing
   b. Allowable soil pressure – for bearing and for settlement: considering soil adjacent foundation, water table, etc.
   c. Material on which footing is to be placed
   d. Scour depth

4. **Construction Considerations**
   a. Water table: Fluctuations, control in excavations, pumping, tremie seals, etc.
   b. Adjacent structures: Protection against damage from excavation, pile driving, drainage, etc.
   c. Pile driving: Difficulties or unusual conditions which may be encountered
   d. Excavation: Control of earth slopes including shoring, sheeting, bracing, and special procedures, variation in, type of material encountered, etc.

**Additional Information:** The Contractor shall provide to the Design Engineer, in addition to the final written report, the following:

1. Name of the Engineer and/or Geologist at the site responsible for the field boring logs and interpretation of the geologic profile.
2. Name of the driller. Type of equipment used.
3. Method (or combination) of drilling used.
4. Size of drive hammer and free fall used on sampler in dynamic tests.
5. Type of size of core barrels.
6. Description of sampler(s).
7. Diameter of any casing used.
9. Deviation from sampling and field-testing equipment requirements as specified by current ASTM and/or AASHTO Standard.

**L. ACCEPTANCE**

The Design Engineer, upon review of the final written report and boring logs, shall exercise final authority as to whether the Contractor has provided sufficient information or if additional data or boring is required. The Design Engineer further reserves the right to review all phases of the geotechnical report including all field and laboratory data, computations, and analysis.