EASTERN MICHIGAN UNIVERSITY

PAVEMENT RECOMMENDATIONS
GEOTECHNICAL GUIDELINES
CONSULTANT SITE DESIGN GUIDELINES
CONSTRUCTION SPECIFICATIONS

PREPARED FOR:
EASTERN MICHIGAN UNIVERSITY
YPSILANTI, MICHIGAN

APRIL 22, 2013
PROJECT NO. G130086

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engineers | scientists | architects | constructors

TABLE OF CONTENTS

LIST OF TABLES

LIST OF APPENDICES

LIST OF ABBREVIATIONS/ACRONYMS

AASHTO	American Association of State Highway and Transportation Officials
ACI	American Concrete Institute
ADAAG	Americans with Disabilities Act Accessibility Guidelines
ANSI	American National Standards Institute
ASTM	American Society for Testing and Materials
CBR	California Bearing Ratio
EMU	Eastern Michigan University
FHWA	Federal Highway Administration
FTC&H	Fishbeck, Thompson, Carr & Huber, Inc.
HMA	Hot Mix Asphalt
LID	Low Impact Development
MDOT	Michigan Department of Transportation
MMUTCD	Michigan Manual on Uniform Traffic Control Devices
QA/QC	Quality Assurance/Quality Control
SCS	USDA Soil Conservation Service
SPT	Standard Penetration Test
USDA	U.S. Department of Agriculture

PAVEMENT RECOMMENDATIONS

BACKGROUND INFORMATION

Fishbeck, Thompson, Carr & Huber, Inc. (FTC&H) reviewed existing available data and completed an onsite inspection of existing on-campus roads and parking lots in December 2012. Readily available data reviewed included the following:

- USDA Soil Conservation Service *Soil Survey of Washtenaw County June 1977*
- Washtenaw County Road Commission minimum pavement requirements from their website
- Wayne County Road Commission minimum pavement requirements from their website
- Washtenaw County Water Resource Commission website
- Eastern Michigan University Physical Plant website
- Federal Highway Administration Publication No. NHI-05-037 Geotechnical Aspect of Pavements
- City of Ypsilanti construction standards
- Michigan Department of Transportation (MDOT) Standard Plans
- FTC&H reference specifications

CAMPUS SOILS FROM USDA SOIL CONSERVATION SURVEY

According to the Washtenaw County Soil Survey, the predominant soil series (58.2%) on the Eastern Michigan University (EMU) Campus is St. Clair clay loam (Map Symbol StB, StC). The permeability of this soil is very slow. As slopes increase, stormwater runoff is rapid, and the erosion potential is severe. Unified soil classification for this soil series is CL and CH; AASHTO Classification A-6 and A-7 (See Appendix 1).

Included in the St. Clair soil mapping are small areas (approximately 7.1%) of Blount loam (Map Symbol BbB). This poorly drained soil of 2 to 6 percent slopes is typically found on foot slopes and along drainageways (Huron River). It consists of clay loam to heavy clay loam with slow permeability and seasonally high water table. Unified classification ML, CL, CH; AASHTO Classification A-4, A-6, and A-7 (See Appendix 1).

Soil mapping on campus also displays an area (20.5%) of Boyer loamy sand (Map Symbol BnB) extending from east to northwest across campus toward the Huron River (see map). The soil series is typified by loamy and sandy deposits underlain by coarse gravel. These soils are found on outwash plains, kames, valley trains, terraces, and moraines. Permeability of this soil is moderately rapid. Unified classification is SM, SC, SP, SP-SM; American Association of State Highway and Transportation Officials (AASHTO) Classification is A-2, A-4, and A-6 (See Appendix 1).

Small areas (1.3%) of Kibbie (Map Symbol KnA) sandy loam, clay loam, and silt loam, and Sisson (Map Symbol SnB) (5.1%) sandy loam, clay loam, and silt loam are found on west campus (See Appendix 1).

This generalized description of EMU campus soils is based on existing soil mapping from the USDA Soil Conservation Service (SCS) and on preliminary onsite observations by FTC&H and conversations with EMU personnel. Actual onsite soils and characteristics should be confirmed by soil borings and laboratory testing on a project specific basis.

GLOSSARY OF TERMS USED IN SOIL SURVEY OF WASHTENAW COUNTY

Glacial Till - unsorted nonstratified glacial drift consisting of clay, silt, sand, and boulders transported/ deposited by glacial ice.

Outwash - cross bedded (sorted, stratified) gravel, sand, silt deposited by glacial melt water.

Kames - irregular short ridge or hill of stratified glacial drift.

Valley train - material deposited by the stream in a valley below a glacier.

Terrace - an old alluvial (deposited on land by streams) plain bordering a river or lake.

Loam - soil containing relative equal amounts of sand, silt and clay (40/40/20). Loam soils generally contain more nutrients, moisture, and humus than sandy soils; have better drainage and infiltration of water and air than silty soils; and are easier to till than clay soils.

Sand - rock or mineral fragments that range in size from 2.0 mm to 0.074 mm.

Silt - individual mineral particles in a soil that range in size from 0.002 mm (clay) to 0.074 mm (fine sand).

Clay - mineral soil particles less than 0.002 mm.

ENGINEERING IMPLICATIONS OF CAMPUS SOIL MAPPING

Soils on EMU's Campus are predominantly fine grained silts and clays with moderate to poor drainage characteristics, mostly low permeability, potential for frost susceptibility, typical reduced strength when wet, potential to become plastic when wet, highly erodible with steeper slopes, and some areas of potential high water table.

The SCS soil mapping also displays an area with deposits (Boyer Soil Series) of somewhat coarser soils with good/fair drainage characteristics underlain by gravelly soils (map symbol BnB).

Design and construction of roads and parking surfaces on campus need to take characteristics of these near surface soils into account. Drainage of the pavement structure is a critical component of both the design and construction of roads and parking lots. By providing positive drainage requirements in the design and during construction, infiltrating surface water can be removed from the pavement structure and not allowed to pond and adversely affect the properties of the subgrade fine grained soils.

The areas of coarser soils may potentially be used for Low Impact Development (LID) design strategies such as bioswales, bioretention basins, and infiltration trenches. Additional subsurface investigation is required to evaluate if these areas are suitable for use in LID design strategies.

RECOMMENDED DESIGN STRATEGIES

1. Use well-drained base aggregates and well drained subbase, if required; connect to underdrains; include good drainage as design criteria (80% of infiltrating water to be removed from pavement structure within 24 hours of cessation of rainfall) and require a design drainage coefficient of 1.0.
2. Shape and slope clay subgrades to promote lateral movement of infiltrating water within base and subbase, if applicable, and along subgrade to underdrains for timely removal of subsurface water from the pavement structure.
3. Use geosynthetics for reinforcement of soft soils particularly along truck or bus routes, if recommended by geotechnical evaluation.
4. Stabilize heavy clay subgrades, if recommended by geotechnical evaluation.
5. Investigate subsurface soil properties in areas of well drained soils for use as potential bioswales, bioretention basins, and infiltration trenching (LID design strategies).
6. Include both flexible and rigid pavement options in the design recommendations requested from geotechnical consultants.
7. Require pavement design be based on AASHTO methodology.
8. Require a detailed geotechnical investigation prior to design to evaluate existing subgrade soils and recommend pavement cross-section.

RECOMMENDED CONSTRUCTION STRATEGIES

1. Require inspection/testing services during construction activities.
2. Incorporate detailed Quality Assurance/Quality Control (QA/QC) requirements into the contract specifications.
3. Specify and enforce proof rolling to identify and correct soft, unstable subgrade soils prior to placement of the subbase and/or base course.
4. Require pavement contractor to be present during proof rolling process.
5. Implement use of penalties for nonconformance of road and parking lot construction contracts.
6. Implement use of warranties of up to 3 years and methodology for enforcement.

IMPLEMENTATION OF DESIGN AND CONSTRUCTION STRATEGIES

1. Prepare geotechnical guidelines and requirements for soil borings and geotechnical evaluation prior to design and construction of roads and parking lots on EMU's campus.
2. Prepare consultant design guidelines displaying minimum design requirements for all campus roads and parking lots.
3. Prepare detailed construction specifications for both bituminous and concrete paving.
4. Require pre-pave meetings prior to construction.
5. Incorporate QA/QC specifications into standard contract documents.
6. Incorporate warranties and penalties specifications to be incorporated into standard contract documents.

GEOTECHNICAL GUIDELINES

NOTE: These guidelines are intended as suggested minimum standards. The geotechnical engineer shall exercise prudent engineering judgment and shall be responsible for selecting testing methods and frequencies that are appropriate to the scope of the project description. Any suggested deviations from these proposed minimum standards shall be indicated clearly in the proposal for services to be rendered. If, during the process of the investigation, the geotechnical engineer discovers that it is necessary to expand or change the scope of the investigation to accomplish the result described below, he or she shall notify EMU in writing.

It is EMU's desire that the pavement system for light duty, standard duty, and heavy duty pavements be designed and constructed to last a <u>minimum</u> of 15 years without major rehabilitation or replacement.

A. The soils engineer should take this into account in their recommendations for site preparation and recommendations for design pavement cross-sections.

B. Soil subgrade treatment, full depth reclamation, geotextile reinforcement, permeable aggregate bases, granular sub bases, underdrains should be recommended if the soils engineer believes they are necessary for long-term pavement performance for the specific site and subsurface conditions.

SCOPE OF WORK

The purpose of the investigation is to provide a detailed soil evaluation report consisting of borings, soil sampling, and laboratory testing. The report should also include the geological profile, subsurface analysis, soil characteristics, and recommendations for pavement types, pavement cross-sections, related earthwork, and recommendation for onsite construction. The report will provide the basic engineering data necessary to define and develop the design and construction documents for the project.

INVESTIGATION REPORT

The geotechnical engineer may use an existing topographical map or aerial map for boring locations with any field adjustments shown. Two benchmarks shall be located at the site and shall be referenced to U.S. Geological Survey or official EMU datum. If a benchmark has been established by a topographic survey for the project or previous survey, the report shall use or reference those benchmarks.

A. The investigation report shall be signed by a registered professional engineer, licensed, and practicing geotechnical engineering in the State of Michigan and shall bear his or her seal. Three (3) bound copies and one (1) electronic (read-only) version of the report are to be submitted to EMU and one (1) hard copy and electronic version to the civil engineering consultant.

B. The report submitted by the geotechnical engineer describing the results of the investigation should include at a minimum the following information:

1. Executive summary at the beginning of the report.
2. A map depicting the location of each boring and indicating the general limits of intersections, entrance drives, parking lots, and reference benchmarks location, if applicable.
3. A log of each boring providing:
   a. Date of boring.
   b. Boring number.
   c. Project name and location.
   d. Client: Eastern Michigan University.
   e. Ground surface elevation at each hole related to the benchmarks or topographical map.
   f. Method used for drilling and sampling.
   g. Existing pavement structure; asphalt or concrete, aggregate base, subbase, if applicable.
   h. Soil strata with description and classification made from the Unified Soil Classification System (ASTM D2488) or AASHTO Classification System.
   i. Sample depths and types.
   j. Penetration resistance (Standard Penetration Test (SPT) and N value) (ASTM D1586).
   k. Groundwater and soil moisture observations with depth.
   l. Rock coring with Rock Quality Designation values, if authorized.
   m. Soil physical and vegetation observations.
   n. Summaries of all field and laboratory tests (pocket penetrometer, etc.).
4. The text of the report shall describe:
   a. Project location.
   b. Topography.
   c. Description of subsurface materials including debris, groundwater, or any unusual conditions that would affect the pavement cross-section design and/or construction.
   d. Important vegetation, including location map.
   e. Field methodology.
   f. Laboratory methods.
5. The report shall discuss pertinent engineering properties of the materials encountered such as:
   a. Laboratory index test results.
   b. *In situ* soil moisture with depth.
   c. Depth to bedrock.
   d. Frost susceptibility.
   e. Infiltration values.
   f. Perimeter drains and/or underdrain requirements.

6. California Bearing Ratio (CBR) or other suitable subgrade modulus used for pavement design.
7. Lateral earth pressure on retaining walls (at-rest, active, and passive) and the corresponding soil density, angle of internal friction, and estimated coefficient of friction, if required.
8. Dewatering requirements for the proposed construction.
9. Modification or Stabilization of site subgrade soils, if required:
   a. For improving the workability of soils having excessive moisture content.
   b. Suitability of site soils for stabilization or modification with lime, fly ash, or Portland cement.
   c. Recommended concentrations, mixing procedures, depth of treatment, and construction requirements.
   d. Utilize MDOT standard specifications for methods and materials, where applicable.
   e. Recommend areas for modification or stabilization.
   f. Provide at least two options for owner consideration.
   g. Anticipated soil improvements, volume changes, and benefits.
   h. Incorporation into pavement cross-section recommendations, if applicable.
   i. Required undercuts, if applicable.
10. Site grading and compaction of fill recommendations, including whether existing soils are suitable for utility trench and pavement structure backfill.

C. Pavement recommendations to include pavement cross-sections for both concrete and hot mix asphalt (HMA) pavements, for light duty, standard duty, and heavy duty sections.
   1. HMA - AASHTO Design Guidelines Flexible Pavement Structures 1993 or the Mechanistic-Empirical design approach developed under NCHRP 1-37A.
   2. Concrete - American Concrete Institute (ACI) 330R - current edition; and/or applicable ACI standards.
   3. Recommendation must also include minimum and maximum lay down thicknesses for HMA pavement based on MDOT guidelines for the specified pavement materials.
   4. Surface course asphalt pavement to be a minimum of 1 1/2" thick. Surface course asphalt to be the same thickness for adjacent areas or on the same project.
   5. Minimum aggregate drainage coefficient of 1.0 for aggregate base or aggregate base/subbase combination.
   6. Basis of Pavement Design.

Table 1 – Flexible and Rigid Pavement

Site paving recommendations for light duty, standard duty, and heavy duty pavement, for both concrete and hot mixed asphalt pavement materials, based on the following design criteria:

	Flexible Payment	Rigid Pavement
Basis of Design (years)	20	20
Parking Lots Light Duty; Design ESALs	30,000	50,000
Campus Road Standard Duty; Design ESALs	200,000	300,000
Bus Routes Heavy Duty; Design ESALs	600,000	750,000
Initial Serviceability	4.5	4.5
Terminal Serviceability	2.25	2.25
Standard Deviation	0.45	0.35
Drainage Coefficient (minimum for base/subbase)	1.0	1.0
Reliability	85%	85%
Minimum Recommended Pavement Thickness (Parking Lot Light Duty)	3″	4″

D. Recommendations are to follow applicable MDOT and other State agency design manuals and guidelines and local experience of the geotechnical firm.

E. The use of geogrids and/or geotextile fabrics as a method to reduce pavement sections, provide separation of materials, and reinforce subgrade soils or to improve drainage, may be presented as an alternative design if the geotechnical engineer feels there may be an economic or long-term performance benefit. The design must include recommendations both with and without the geofabrics and geogrids for comparative purposes.

F. Recommended parameters for design of retaining walls and stem walls, if required:
   1. Coefficient of earth pressure at rest, active, and passive.
   2. Recommended backfill, unit weight, and friction angle.
   3. Coefficient of friction/friction angle between rough concrete and bearing soil.
   4. Any other soil or site characteristics which could have detrimental effects on the design and construction of the recommended systems.

SOIL BORINGS

A. The selected geotechnical consultant will responsible for locating and completing soil borings according to the following criteria:
   1. Borings shall be located throughout the paved areas with a minimum of one boring for approximately every 20,000 square feet.
   2. One boring every 300 to 500 linear feet along roadways; locate such that minimum of one boring is located at each intersection.
   3. Additional borings or testing shall be recommended in writing by the geotechnical engineer if deemed necessary or appropriate for this site, such as identifying the extent (horizontally and vertically) of organic or unsuitable soils.

4. One additional boring at every major drive entrance, every 300 linear feet along service drives, entrance roads, or as dictated by the size of the project and any special conditions at the site.
5. Borings shall extend to a minimum depth of 5.0 feet below proposed grade (unless fill situation dictates otherwise) or auger refusal, or deeper if unsuitable soils are found.
6. In addition, one boring every 400 linear feet shall be located along a pipeline route 15 feet deep (minimum), or 5 feet below the invert of the pipe (if known).

B. The geotechnical consultant must note in the report the new locations of any borings that were relocated in the field due to access difficulty or utility conflicts.

C. Unless otherwise stipulated, drilling and testing shall be performed in accordance with the latest editions of applicable ASTM Standards, including, but not limited to ASTM Standards D1586, D1587, and D2113. Soil samples shall be taken at the ground surface, at 2.5-foot intervals below existing grade, up to 15 feet deep, then 5-foot intervals to 50 feet deep, then 10-foot intervals beyond 50 feet, and at each identified change in conditions.

LABORATORY TESTING

A. Laboratory testing shall comply with the latest edition of current applicable ASTM standards
1. Atterberg limits for subgrade soils including *in situ* moisture contents.
2. Grain size analysis for any onsite soils used in pavement structure.
3. Measured or estimated infiltration rates for moderate to well drained soils that may be used for LID design strategies.
4. Estimated or calculated CBRs (soaked) or resilient modulus used as the basis of pavement design for subgrade soils.

CONSULTANT SITE DESIGN GUIDELINES

These guidelines are intended as suggested minimum standards. The consulting engineer shall exercise prudent engineering judgment and be responsible for their project drawings and specifications. Any suggested deviations from these proposed minimum standards shall be indicated clearly in the proposal for services to be rendered. If during the project, the consulting engineer discovers it is necessary to expand or change these requirements, he or she shall notify EMU in writing.

The EMU Site Design Guidelines and Construction Standards have been compiled for Engineers and others retained to provide professional consulting or design services for EMU.

Adherence to the Design Guidelines and Construction Standards is mandatory unless a deviation has been approved in writing by the EMU Design Representative. Any equal or improved concept method or product will be given full consideration.

The Design Guidelines and Construction Standards are not intended to be used as specification items. The architects and engineers are expected to incorporate the items using their own wording and format unless otherwise directed.

The Design Guidelines and Construction Standards are prepared and published by: Physical Plant Division, Eastern Michigan University.

Sections of the Design Guidelines and Construction Standards will be revised and updated as experience or construction developments warrant. Each revised section supersedes all previous editions and directives concerning construction practices for EMU. The EMU website will always contain the most current version with the latest revision date indicated.

GENERAL BACKGROUND INFORMATION

1. The EMU campus is primarily pedestrian and bicycle-oriented:
    a. Clear physical and visual connections are necessary to facilitate safe and convenient pedestrian and bicycle movement across the campus.
    b. Where practicable, vehicular and pedestrian circulation should be separated.

2. When vehicular, pedestrian, and bicycle circulation is shared or crossed, traffic calming devices such as tree-lined streets, changes in paving materials, signage, pavement markings, etc., should be used to ensure pedestrian safety.

3. A physical network of interconnected paths and walkways intermingled with open spaces is essential to linking buildings for pedestrians and bicycles throughout the campus.

4. Visual connectivity also helps pedestrians establish a line of sight and orientation through landmarks.

5. EMU is located adjacent to the Huron River in an area of glacial deposits of moderately well drained to very poorly drained soils.
   a. Subsurface soils range from smaller areas of loamy sand to larger areas of clay loams to heavy clay loams.
   b. To provide long-term performance of paved surfaces, the designer may be required to provide for collection and transmission of both surface and subsurface stormwater runoffs.

REFERENCE GUIDELINES

1. Eastern Michigan University Construction Standards and Guidelines

2. *A Policy on Geometric design of Highways and Streets (2011)* as published by AASHTO, Latest Edition

3. *Guidelines for Residential Subdivision Street Design: A Recommended Practice* as published by the Institute of Transportation Engineers (ITE) for local and collector streets

4. *Guidelines for Geometric Design of Very Low-Volume Local Roads* as published by AASHTO, Latest Edition

5. *Michigan Roundabout Guidelines* as published by MDOT, Latest Edition, and current Federal Highway Administration (FHWA) roundabout guidelines and standards

6. *Americans with Disabilities Act Accessibility Guidelines (ADAAG)*, Latest Edition, and the American National Standards Institute (ICC/ANSI), and local Building Code

7. Any publications or advisories produced by MDOT's Complete Streets Advisory Council

8. Applicable Local Building Codes

9. *Guide for the Development of Bicycle Facilities, AASHTO*, P.O. Box 96716, Washington, DC, 20090-6716, Phone: (888) 227-4860, Latest Edition

10. *Improving Conditions for Bicyclists and Pedestrians*, A Best Practices Report, FHWA, HEP 10, 400 Seventh Street SW, Washington, DC 20590, Latest Edition

11. ITE Recommended Practice *Design and Safety of Pedestrian Facilities,* Latest Edition

12. Michigan Manual on Uniform Traffic Control Devices (MMUTCD), Latest Edition

13. Hot Mix Asphalt - AASHTO Design Guidelines Flexible Pavement Structures 1993 or the Mechanistic-Empirical design approach developed under NCHRP 1-37A

14. Concrete - ACI Publication 330R Guide for the Design and Construction of Concrete Parking Lots. Latest Edition

15. Guidebook of Best Management Practices for Michigan Watersheds, MDEQ Water Quality Division

16. Washtenaw County Water Resource Commissioner: Design Standards, where applicable

17. Low Impact Development Manual for Michigan: A Design Guide for Implementers and Reviewers, Southeast Michigan Council of Government, September 2008

DESIGN ELEMENTS

1. Design Vehicle:
   a. Maximum - AASHTO Bus and WB-40/emergency vehicle.
   b. Minimum passenger car.

2. Design Speed:
   a. Bus Route and Perimeter Roads - 30 mph.
   b. Interior Campus Roads - 30 mph.
   c. Others - in accordance with jurisdictional agency requirements.

3. Lane Width:
   a. Desirable - 12 feet; 14 feet turning lane.
   b. Bike Lanes - 5.0 foot desirable, where applicable.

4. Curb and Gutter:
   a. Use 24-inch standard curbs or reverse curbs as required for surface drainage.
   b. In areas where snow removal operations are expected:
      1) Use 24-inch mountable or rolled curbs.
      2) Check with EMU Physical Plant division for locations where snow removal operations are required on your project
   c. Removal and replacement sections - match existing curb section unless otherwise directed.
   d. Standard curb height is 6.0 inches, can be increased to 8.0 inches to prevent vehicular mountings.

5. Drainage:
    a. The use of underdrains is encouraged in order to extend the life expectancy of campus pavements.
    b. A perforated HDPE (high-density polyethylene) underdrain trench with clean porous stone wrapped in filter fabric is preferred over sock drains. c.Conveyance systems – 10-year design storm.
    d. Spacing of drainage structures - 350 feet maximum or more frequent as determined by engineer.
    e. Comply with requirements of Washtenaw County Water Resource Commissioner, where applicable.
    f. Design and size to interface with existing storm system and available capacity.
    g. Properly locate inlets to ensure proper surface drainage and prevent ponding along campus roads, at pedestrian crosswalks, or within parking areas.
    h. Place drainage structure grates not to interfere with pedestrian movement.
    i. Grates along roads - bicycle safe.
    j. Use double or multiple grates at low points where required.
    k. Consider LID and/or Best Management Practices (BMPs) where practical and cost-effective for stormwater management

6. Ramps and Driveways:
    a. Ramps - MDOT R-28H series.
    b. Driveways - MDOT R-29H series.

7. Parking Spaces:
    a. 9 feet wide by 18 feet long.
    b. Minimum aisle width - 24 feet unless otherwise directed.
    c. All parking 90 degrees unless otherwise directed.
    d. Angle parking requires written permission from EMU.
    e. Comply with current Americans with Disabilities Act of 1990 (ADA) and campus guidelines for handicap parking requirements.

8. Miscellaneous:
    a. Design all concrete structures (precast or cast-in-place) and castings for H-20 vehicle loading.
    b. Sidewalks that are vehicle snow-plowed - minimum 6.0 inches concrete over minimum 6.0 inches free draining aggregate.
    c. Minimum 4.0-inch sidewalks over minimum 6.0-inch free draining aggregate may be used in pedestrian only areas with approval of EMU.

9. Plans:
   a. Plan sheets - 24 inch x 36 inch or 30 inch x 42 inch with north arrow shown.
   b. Scale maximum of 1 inch = 50 feet unless otherwise directed.
   c. Intersections, cul-de-sacs, sidewalks, and driveways - use larger scale (i.e., 1 inch = 10 or 20 feet), as required with spot elevations to clearly indicate surface drainage patterns.
   d. Provide bar scale on all scaled drawings.
   e. Road and Drainage Plans: Use a ground survey based on the current adjustment of the Michigan Coordinate System of 1983 (MCS 83, Act 9, P.A. of 1964, as amended). Provide a statement on the plans by the Professional Surveyor as to how coordinates were developed.
   f. All elevations are to be based on the North American Vertical Datum of 1988. Provide two permanent benchmarks conforming to EMU standards or use existing ones provided by EMU for use in each project and shown on the drawings.

10. Basis of Pavement Design:

Table 1 – Flexible and Rigid Pavements

Site paving recommendations for light duty, standard duty, and heavy duty pavement, for both concrete and hot mixed asphalt pavement materials, based on the following design criteria:

	Flexible Payment	Rigid Pavement
Basis of Design (years)	20	20
Parking Lots Light Duty; Design ESALs	30,000	50,000
Standard Road; Design ESALs	200,000	300,000
Bus Routes Heavy Duty; Design ESALs	600,000	750,000
Initial Serviceability	4.5	4.5
Terminal Serviceability	2.25	2.25
Standard Deviation	0.45	0.35
Drainage Coefficient (minimum for base/subbase)	1.0	1.0
Reliability	85%	85%
Minimum Recommended Pavement Thickness (Parking Lot Light Duty)	3″	4″

11. Deliverables:
    a. Projects are to follow EMU's project development process and consist of the following:
       1) Kick-off Meeting
       2) Conceptual Design (30%)
       3) Preliminary Design (60-75%)
       4) Final Design (95-100%)
       5) Final Deliverable

12. Kick-off Meeting: The kick-off meeting will be held at EMU Physical Plant Building.
    a. Review and finalize project scope.
    b. Establish schedule for project completion.
    c. Introduce team members and establish communication channels.
    d. Obtain readily available data for project development.

13. Conceptual Design (30%) - The Conceptual Design Review will be held at EMU's Physical Plant Building. Provide a clearly defined conceptual design plan and present it in a form that results in understanding and acceptance by EMU.
    a. Existing conditions plan.
    b. Conceptual site plan.
    c. Recommended alternative solutions, if applicable.
    d. Rough construction cost estimates.

14. Preliminary Design (60-75%) - The Preliminary Design Review will be held at EMU's Physical Plant Building. This meeting will include an onsite review. Preliminary designs are intended to advance project concepts to a detailed understanding and quantification of all the major project elements.
    a. Preliminary Plans.
    b. Technical Specifications.
    c. Updated Cost Estimate.
    d. Include any field investigations.
    e. Based on approved conceptual design and comments.

15. Final Design (95-100%) - The Final Design Review will be held at EMU's Physical Plant Building. The final project design will incorporate comments provided by EMU and other agencies regarding the preliminary design submittal and onsite review. The final project design process converts the preliminary design submittal (text and drawings, etc.) into a standalone and comprehensive set of final design drawings (construction drawings) and technical specifications for project bidding and construction.
    a. Incorporate comments from preliminary design review meeting.
    b. Final Design Drawings.
    c. Technical Specifications.
    d. Final Construction Quantities and Final Estimate of Costs.
    e. Contract Bidding Documents and General Contract Conditions.
    f. Construction permits, if required.

16. Post-Construction Deliverable: "As-Built Drawings:"
    a. Clearly document all changes made during construction to the project design in "As-built drawings" modified by the engineer / designer after completion of construction.

17. Standard Sections: See Appendix 2.

Appendix 1

Report- Engineering Properties Washtenaw County, Michigan

Absence of an entity indicates that the data were not estimated.
" * " denotes the representative texture; other possible textures follow the dash.

Map unit symbol and soil name	Depth	USDA texture	Classification	
			Unified	AASHTO
	In			
BbB—Blount loam, 2 to 6 percent slopes				
Blount	0-10	*Loam	CL	A-4, A-6
	10-23	*Clay, Silty clay loam, clay loam	CH, CL	A-6, A-7-6
	23-30	*Clay loam, Silty clay loam	CH, CL, MH, ML	A-6, A-7-6
	30-60	*Clay loam, Silty clay loam	CL	A-6, A-7
BnB—Boyer loamy sand, 0 to 6 percent slopes				
Boyer	0-8	*Loamy sand	SP-SM, SM	A-1, A-2-4
	8-18	*Loamy sand, Sandy loam	SC-SM, SM, SP-SM	A-1-b, A-2-4, A-4
	18-32	*Sandy loam, Gravelly sandy loam	SC, SC-SM	A-2-4, A-4
	32-60	*Gravelly coarse sand	GP, GP-GM, SP, SP-SM	A-1-b, A-2, A-3
Fd—Fill land				
Fill land	—	—	—	—
KnA—Kibbie fine sandy loam, 0 to 4 percent slopes				
Kibbie	0-12	*Fine sandy loam	CL, ML, SC, SM	A-4, A-6
	12-29	*Sandy clay loam, Silt loam, silty clay loam	CL, SC	A-4, A-6, A-7
	29-60	*Stratified fine sand to silt loam	CL, ML, SC, SM	A-2, A-4
SnC—Sisson fine sandy loam, 6 to 12 percent slopes				
Sisson	0-9	*Fine sandy loam	CL, ML, SC, SM	A-4
	9-37	*Fine sandy loam, Sandy clay loam, silty clay loam	CL, SC	A-6, A-7
	37-60	*Stratified fine sand to silt loam	CL, ML, SC, SM	A-2, A-4
StB—St. Clair clay loam, 2 to 6 percent slopes				
St. clair	0-9	*Clay loam	CL	A-6, A-7
	9-25	*Clay, Silty clay	CH, MH	A-7
	25-60	*Clay, Silty clay	CH, MH	A-7
StC—St. Clair clay loam, 6 to 12 percent slopes				
St. clair	0-9	*Clay loam	CL	A-6, A-7
	9-25	*Clay, Silty clay	CH, MH	A-7
	25-60	*Clay, Silty clay	CH, MH	A-7

Data Source: NRCS Web Soil Survey
-Washtenaw County Version 11, 09/27/2012.

PLOT INFO Z:\2013\130086\CAD\GIS\Map Document\Soils.mxd Date 3/5/2013 1:23:49 PM User mb2

ftc&h

engineers
scientist
architects
constructors

fishbeck, thompson, carr & huber, inc.

Hard copy is intended to be 11"x17" when plotted. Scale(s) indicated and graphic quality may not be accurate for any other size.

Eastern Michigan University

Ypsilanti, Michigan

Campus SCS Soil Mapping

PROJECT NO.
G130086

FIGURE NO.
1

Engineering Properties

This table gives the engineering classifications and the range of engineering properties for the layers of each soil in the survey area.

Depth to the upper and lower boundaries of each layer is indicated.

Texture is given in the standard terms used by the U.S. Department of Agriculture. These terms are defined according to percentages of sand, silt, and clay in the fraction of the soil that is less than 2 millimeters in diameter. "Loam," for example, is soil that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the content of particles coarser than sand is 15 percent or more, an appropriate modifier is added, for example, "gravelly."

Classification of the soils is determined according to the Unified soil classification system (ASTM, 2005) and the system adopted by the American Association of State Highway and Transportation Officials (AASHTO, 2004).

The Unified system classifies soils according to properties that affect their use as construction material. Soils are classified according to particle-size distribution of the fraction less than 3 inches in diameter and according to plasticity index, liquid limit, and organic matter content. Sandy and gravelly soils are identified as GW, GP, GM, GC, SW, SP, SM, and SC; silty and clayey soils as ML, CL, OL, MH, CH, and OH; and highly organic soils as PT. Soils exhibiting engineering properties of two groups can have a dual classification, for example, CL-ML.

The AASHTO system classifies soils according to those properties that affect roadway construction and maintenance. In this system, the fraction of a mineral soil that is less than 3 inches in diameter is classified in one of seven groups from A-1 through A-7 on the basis of particle-size distribution, liquid limit, and plasticity index. Soils in group A-1 are coarse grained and low in content of fines (silt and clay). At the other extreme, soils in group A-7 are fine grained. Highly organic soils are classified in group A-8 on the basis of visual inspection.

If laboratory data are available, the A-1, A-2, and A-7 groups are further classified as A-1-a, A-1-b, A-2-4, A-2-5, A-2-6, A-2-7, A-7-5, or A-7-6. As an additional refinement, the suitability of a soil as subgrade material can be indicated by a group index number. Group index numbers range from 0 for the best subgrade material to 20 or higher for the poorest.

Rock fragments larger than 10 inches in diameter and 3 to 10 inches in diameter are indicated as a percentage of the total soil on a dry-weight basis. The percentages are estimates determined mainly by converting volume percentage in the field to weight percentage.

Percentage (of soil particles) passing designated sieves is the percentage of the soil fraction less than 3 inches in diameter based on an ovendry weight. The sieves, numbers 4, 10, 40, and 200 (USA Standard Series), have openings of 4.76, 2.00, 0.420, and 0.074 millimeters, respectively. Estimates are based on laboratory tests of soils sampled in the survey area and in nearby areas and on estimates made in the field.

Liquid limit and *plasticity index* (Atterberg limits) indicate the plasticity characteristics of a soil. The estimates are based on test data from the survey area or from nearby areas and on field examination.

References:
American Association of State Highway and Transportation Officials (AASHTO). 2004. Standard specifications for transportation materials and methods of sampling and testing. 24th edition.
American Society for Testing and Materials (ASTM). 2005. Standard classification of soils for engineering purposes. ASTM Standard D2487-00.

Report—Engineering Properties

Absence of an entry indicates that the data were not estimated. The asterisk '*' denotes the representative texture; other possible textures follow the dash.

Engineering Properties– Washtenaw County, Michigan													
Map unit symbol and soil name	Depth	USDA texture	Classification		Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
			Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
	In				Pct	Pct					Pct	
BbB—Blount loam, 2 to 6 percent slopes												
Blount	0-10	*Loam	CL	A-4, A-6	0	0-5	95-100	95-100	90-100	80-95	25-40	8-20
	10-23	*Clay, Silty clay loam, clay loam	CH, CL	A-6, A-7-6	0-1	0-5	95-100	90-100	80-90	75-85	35-60	15-35
	23-30	*Clay loam, Silty clay loam	CH, CL, MH, ML	A-6, A-7-6	0-1	0-5	95-100	90-100	80-90	70-90	35-55	10-30
	30-60	*Clay loam, Silty clay loam	CL	A-6, A-7	0-1	0-10	90-100	90-100	80-100	70-90	30-45	10-25
BnB—Boyer loamy sand, 0 to 6 percent slopes												
Boyer	0-8	*Loamy sand	SP-SM, SM	A-1, A-2-4	0	0-5	95-100	75-95	30-80	10-35	15-20	NP-4
	8-18	*Loamy sand, Sandy loam	SC-SM, SM, SP-SM	A-1-b, A-2-4, A-4	0	0-5	95-100	75-95	35-70	10-40	15-30	NP-10
	18-32	*Sandy loam, Gravelly sandy loam	SC, SC-SM	A-2-4, A-4	0	0-5	90-100	70-95	40-70	25-40	15-25	5-10
	32-60	*Gravelly coarse sand	GP, GP-GM, SP, SP-SM	A-1-b, A-2, A-3	0	0-10	40-95	30-85	20-60	0-10	0-14	NP
Fd—Fill land												
Fill land	—	—	—	—	—	—	—	—	—	—	—	—

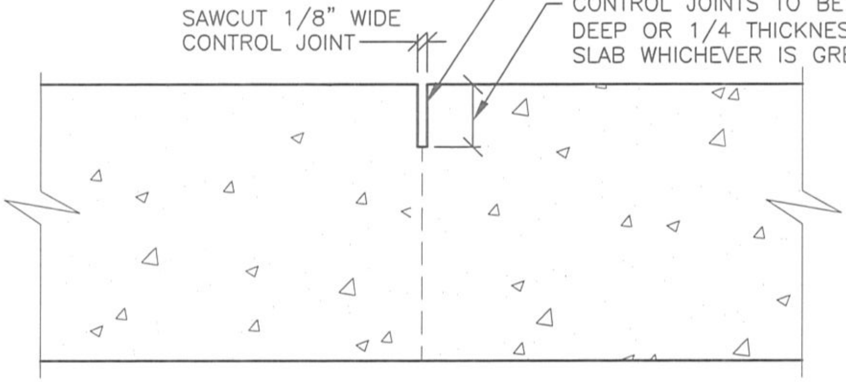
Engineering Properties– Washtenaw County, Michigan												
Map unit symbol and soil name	Depth	USDA texture	Classification		Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
			Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
	In				Pct	Pct					Pct	
KnA—Kibbie fine sandy loam, 0 to 4 percent slopes												
Kibbie	0-12	*Fine sandy loam	CL, ML, SC, SM	A-4, A-6	0	0	100	100	75-95	40-60	15-30	NP-11
	12-29	*Sandy clay loam, Silt loam, silty clay loam	CL, SC	A-4, A-6, A-7	0	0	90-100	85-100	80-100	35-90	25-45	9-25
	29-60	*Stratified fine sand to silt loam	CL, ML, SC, SM	A-2, A-4	0	0	100	95-100	70-95	30-80	15-30	NP-10
SnC—Sisson fine sandy loam, 6 to 12 percent slopes												
Sisson	0-9	*Fine sandy loam	CL, ML, SC, SM	A-4	0	0	100	100	60-95	35-65	20-30	NP-10
	9-37	*Fine sandy loam, Sandy clay loam, silty clay loam	CL, SC	A-6, A-7	0	0	100	100	80-100	40-90	25-45	10-25
	37-60	*Stratified fine sand to silt loam	CL, ML, SC, SM	A-2, A-4	0	0	100	95-100	65-95	25-90	15-30	NP-10
StB—St. Clair clay loam, 2 to 6 percent slopes												
St. clair	0-9	*Clay loam	CL	A-6, A-7	0	0-5	95-100	85-100	70-100	50-80	35-45	15-25
	9-25	*Clay, Silty clay	CH, MH	A-7	0	0-5	95-100	85-100	75-100	65-95	50-70	20-40
	25-60	*Clay, Silty clay	CH, MH	A-7	0	0-5	95-100	85-100	75-100	65-95	50-70	20-40
StC—St. Clair clay loam, 6 to 12 percent slopes												
St. clair	0-9	*Clay loam	CL	A-6, A-7	0	0-5	95-100	85-100	70-100	50-80	35-45	15-25
	9-25	*Clay, Silty clay	CH, MH	A-7	0	0-5	95-100	85-100	75-100	65-95	50-70	20-40
	25-60	*Clay, Silty clay	CH, MH	A-7	0	0-5	95-100	85-100	75-100	65-95	50-70	20-40

Data Source Information

Soil Survey Area: Washtenaw County, Michigan
Survey Area Data: Version 11, Sep 27, 2012

Appendix 2

EASTERN MICHIGAN UNIVERSITY



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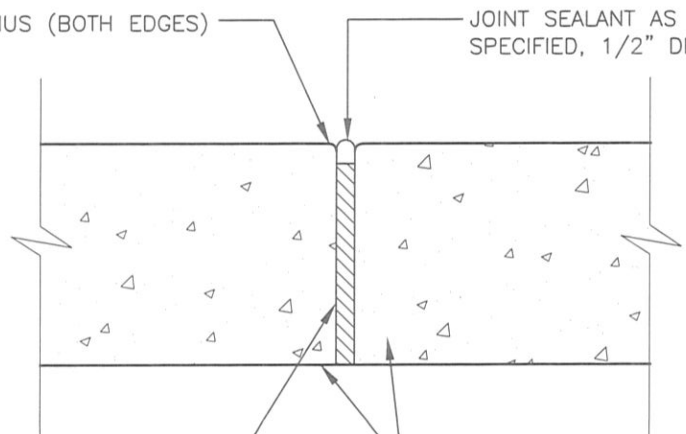

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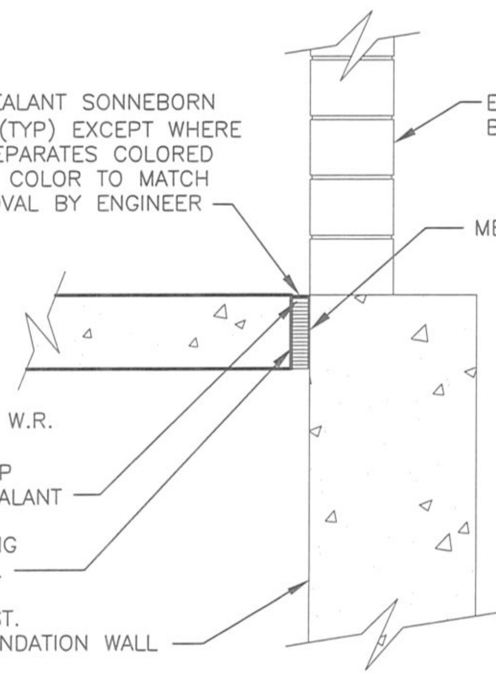

EXPANSION JOINT DETAIL AT BUILDING

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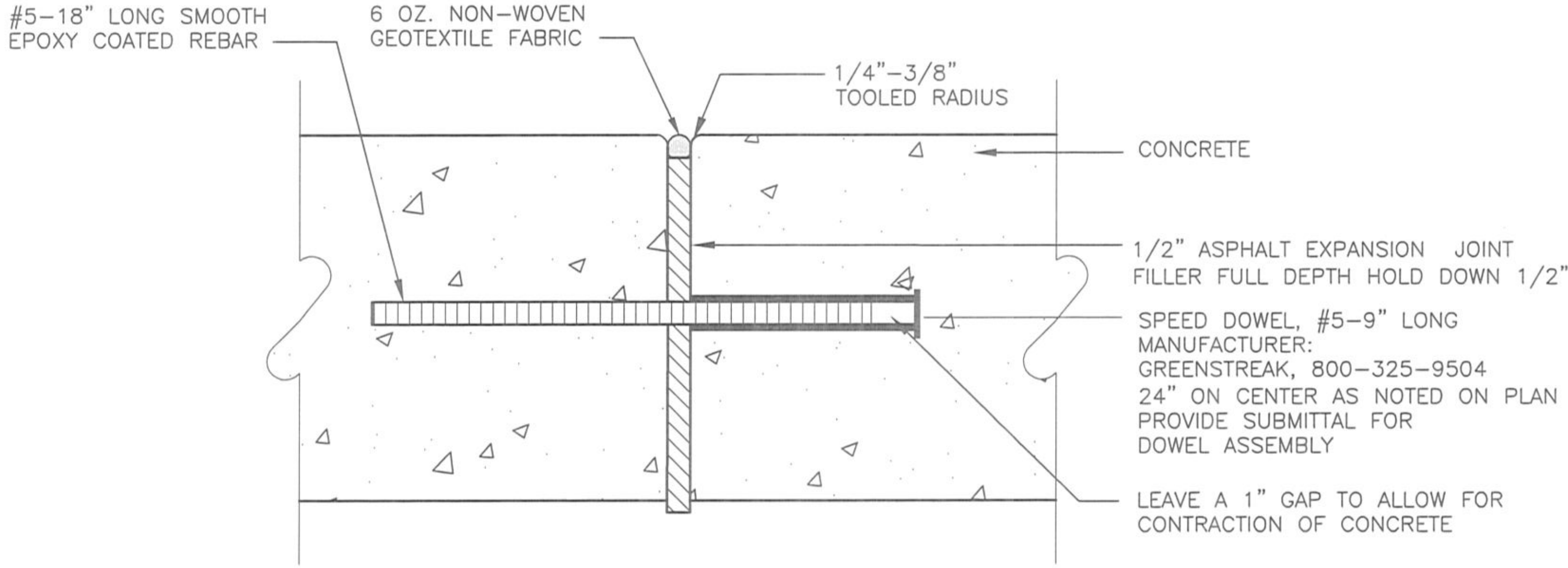

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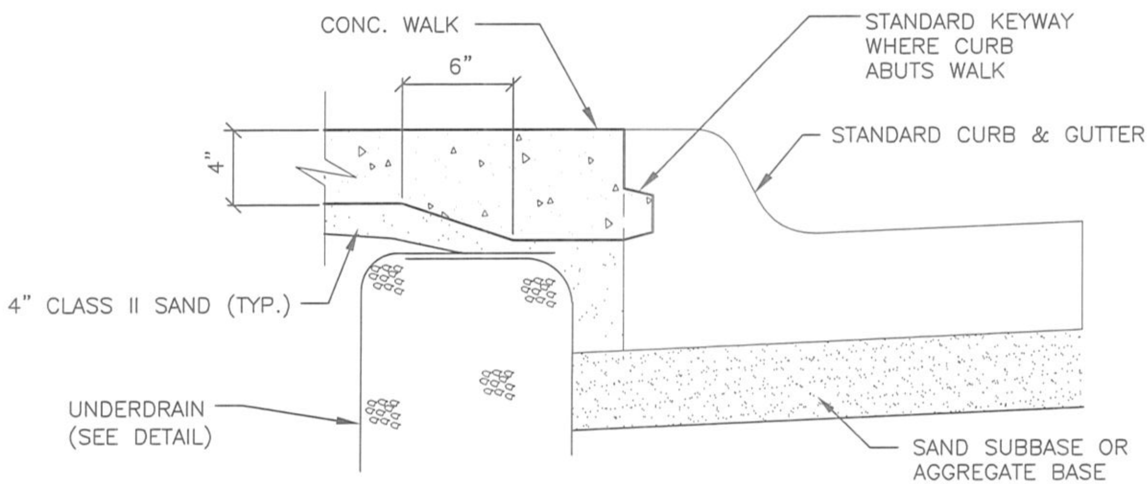

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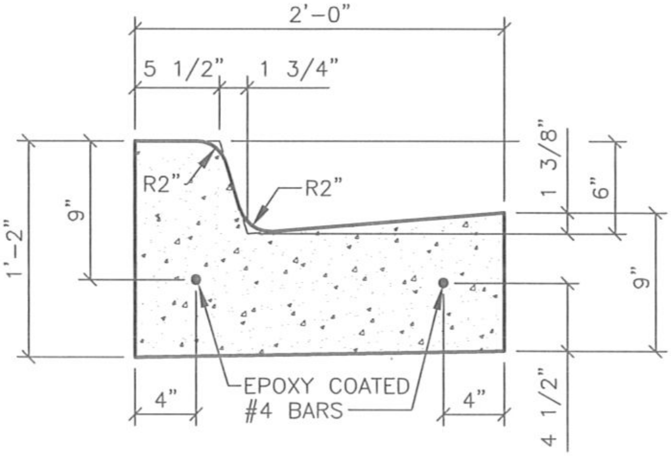

STANDARD CROWN
CURB & GUTTER

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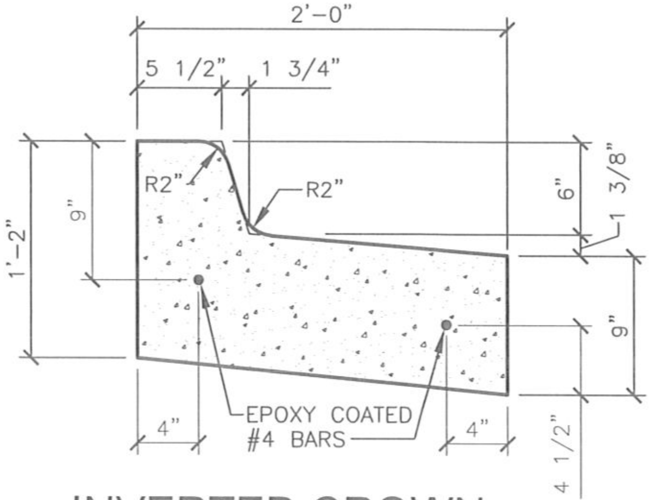

INVERTED CROWN
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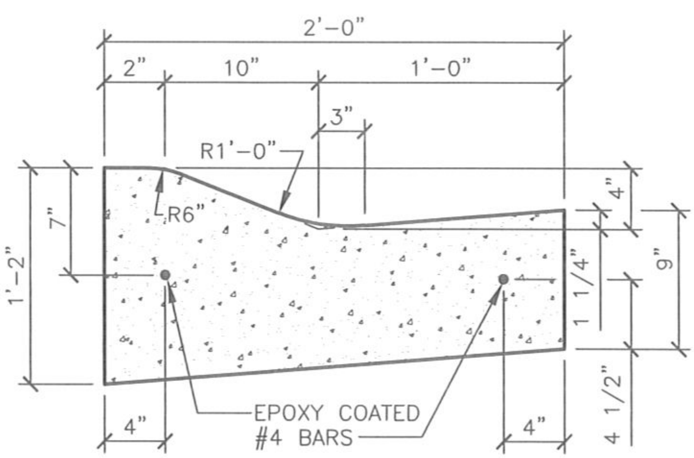

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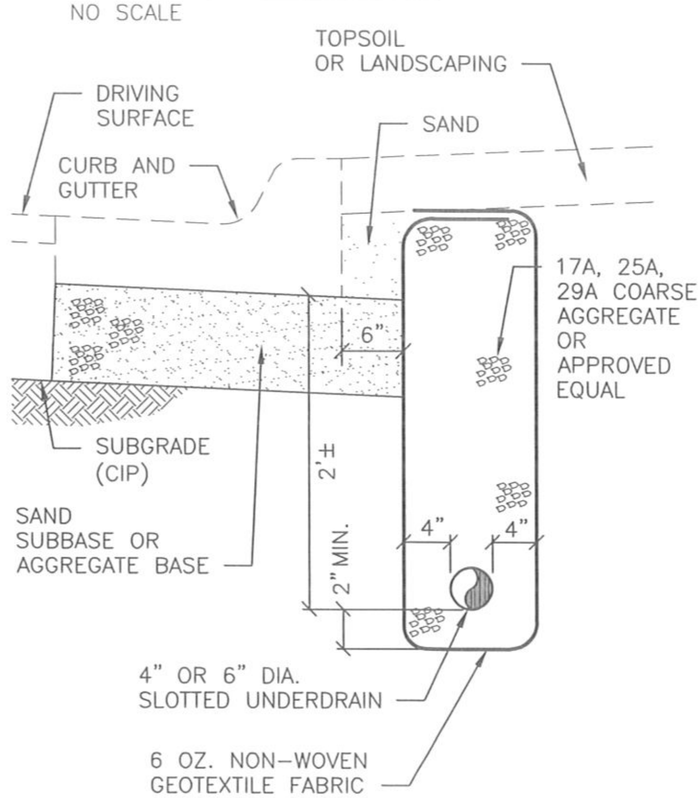

ROADWAY
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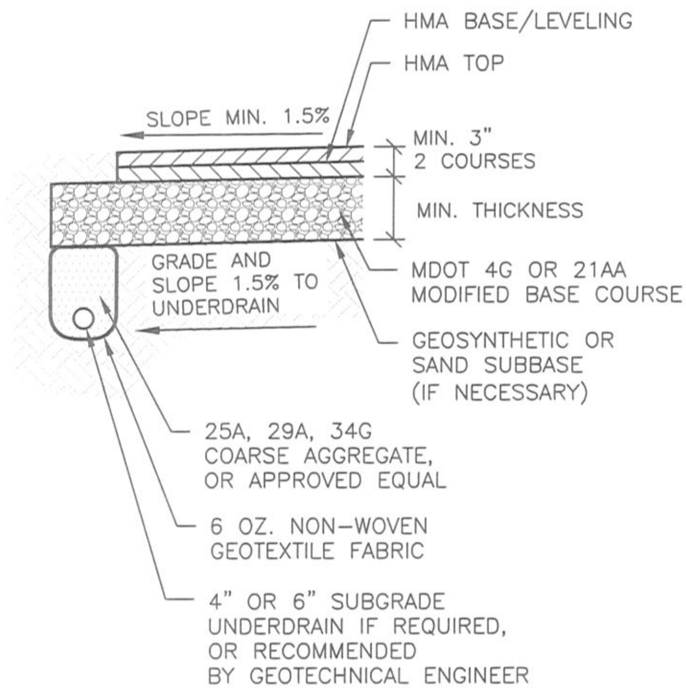

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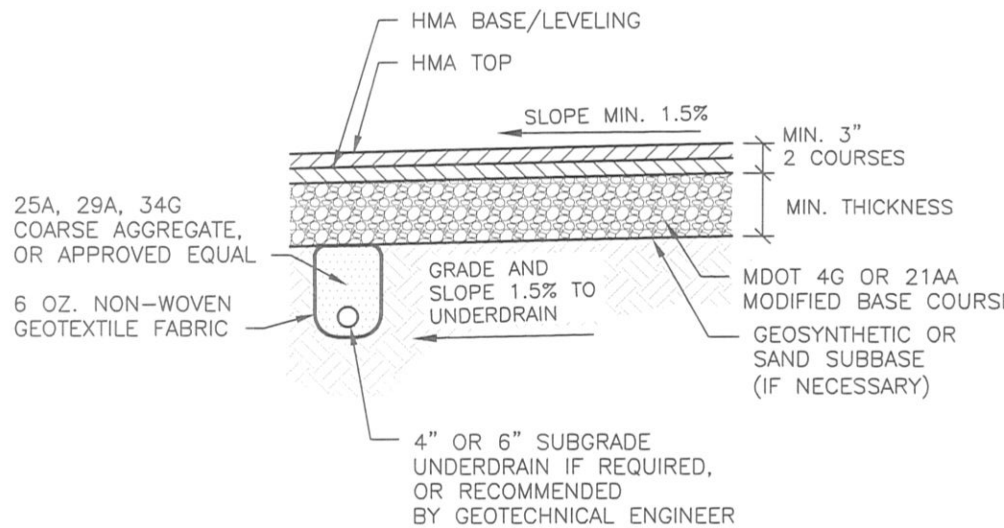

FLEXIBLE PAVEMENT
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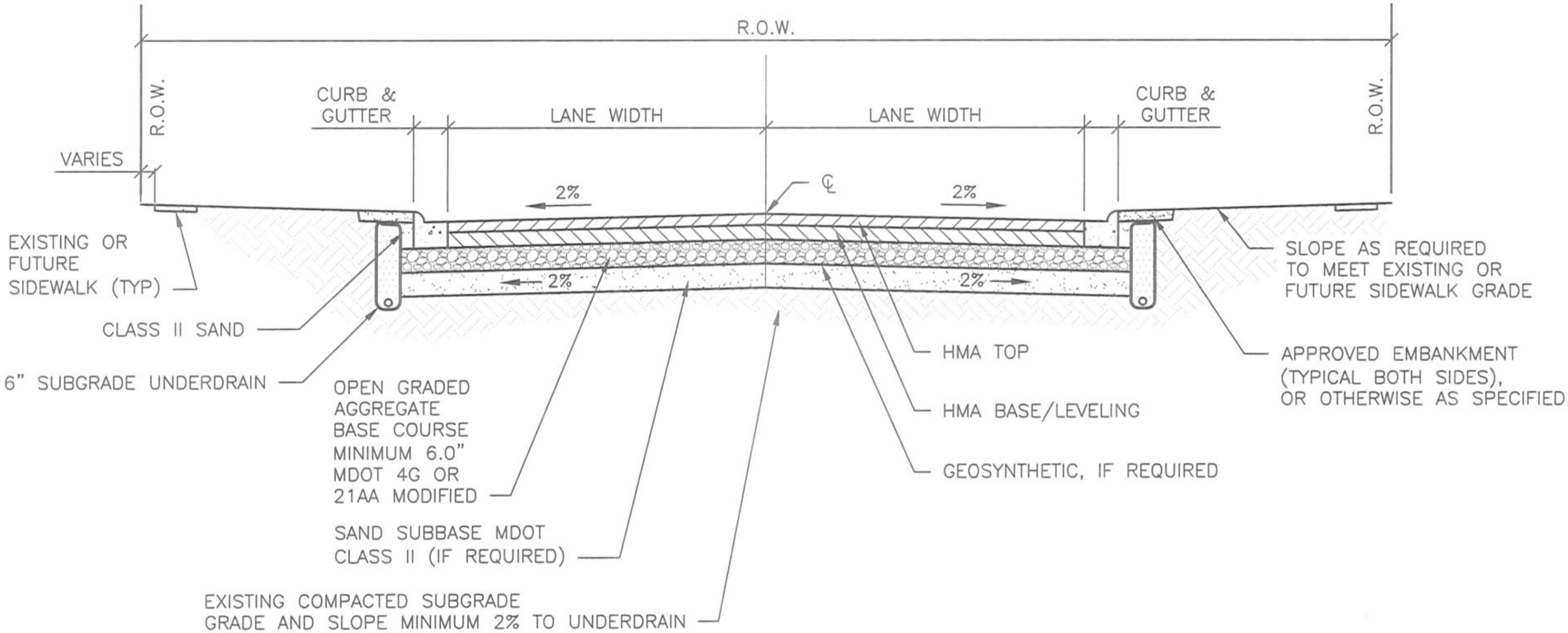

FLEXIBLE PAVEMENT
ROAD CROSS SECTION
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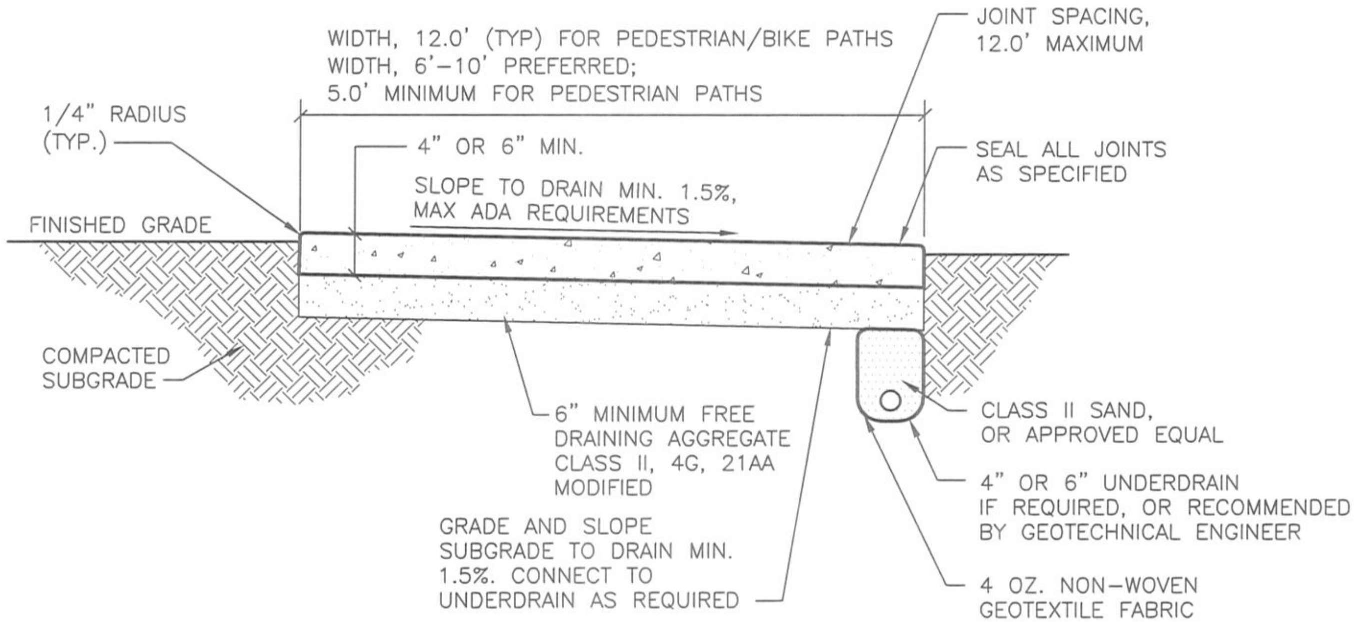

SIDEWALK DETAIL

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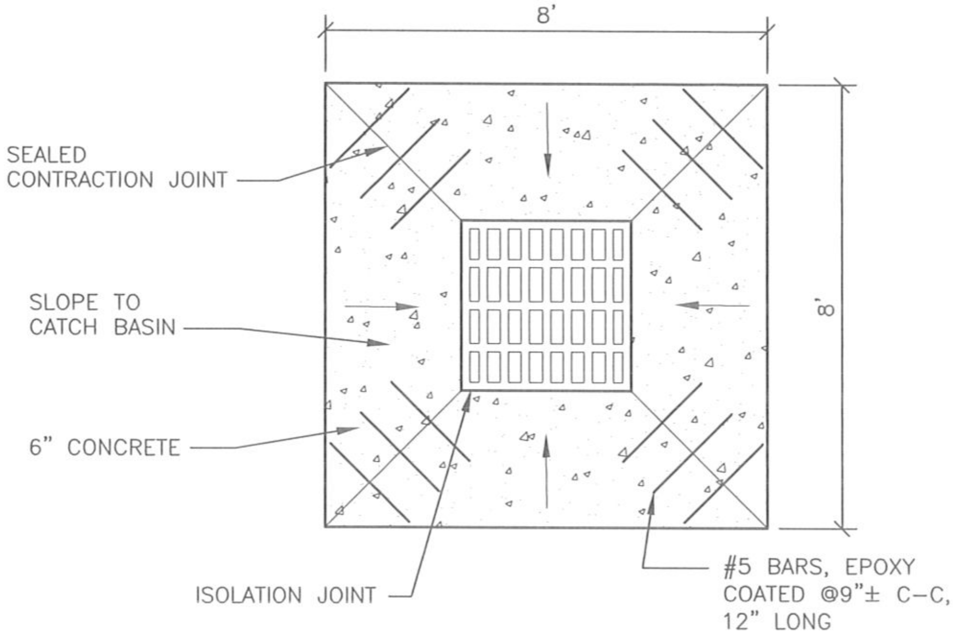

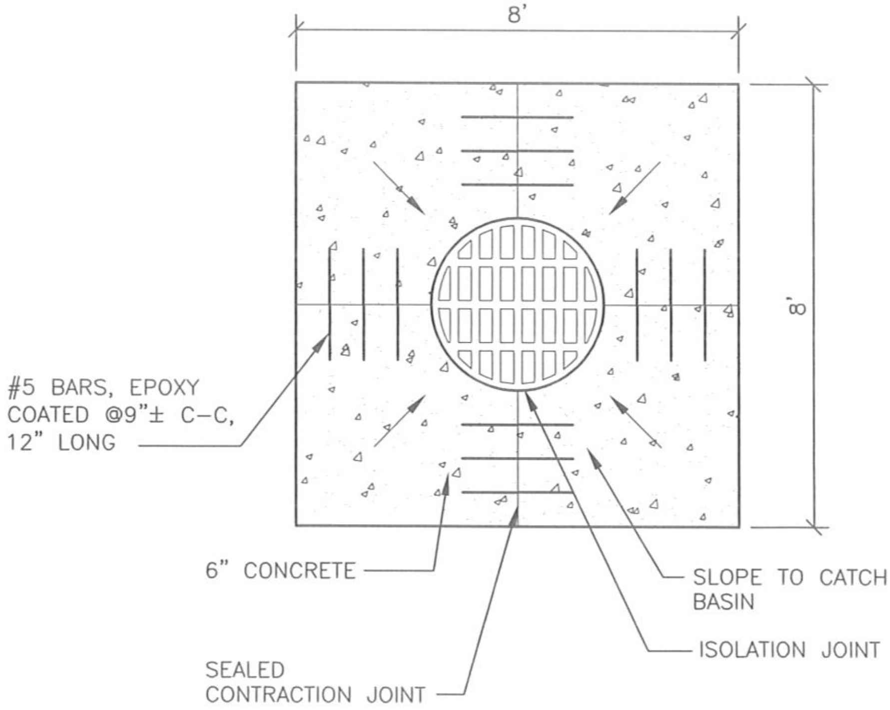

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