Article 5 Streets

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I. Street and Pavement Design

A. General

1. Adoption of Standards by Reference

    a) ADA/PROWAG shall be followed for all street designs.

    b) AASHTO and NACTO design guidelines shall be followed for all street designs.

    c) Where work is performed in the DDA boundary see also Appendix D: Street Design Manual.

2. Plan Information Required

    a) Copies of all calculations and drawings verifying compliance with these Standards are to be submitted to the PSAA for review. Plans shall include all elements per Article 1 (General), Section III.D (Road Plans) of these Standards.

B. Design Criteria for New Public Streets

1. Geometric Design

    a) Geometric design requirements for public streets vary site-by-site and must be established with the PSAA.

2. Calculation of Estimated ADT

    a) The estimated ADT for a street shall be determined by traffic studies and by applying the ITE Trip Generation Handbook average trip generation for each type of existing or expected development.

3. Classification of Streets and Associated Design Speed

    a) Street classifications are based on Michigan Public Act 51 and National Functional Classification (NFC).

    b) Streets shall be classified as either Local, Major Local, Local Collector, Major Collector, Minor Arterial, or Principal Arterial and meet the design requirements as specified in Table A of this Article.

    c) All streets will be sized for the appropriate land use and achieve the function as specified below:

(1) Local or Major Local - The primary function of these streets is to provide access to immediately adjacent properties. These streets provide access to land with little or no through movement, for example short, looping streets or cul-de-sacs.

(2) Minor or Major Collector - The primary function of these streets is to serve traffic between local and arterial streets, and provide access to immediately adjacent residential and non-residential properties.

(3) Minor or Principal Arterial - The function of these streets is to serve as the principal carrier of high-volume traffic flow, connecting areas of principal traffic generation. They should form a reasonably continuous and integrated system, and should help define residential neighborhoods, industrial sites and commercial areas.

4. Right-of-Way and Street Width

a) The minimum right-of-way width and street width as measured from edge-of-metal to edge-of-metal shall be per Table A of this Article.

b) Each street classification shall provide sufficient ROW width to design for all modes of transportation as identified in Article 6 (Drive Approaches, Active Transportation Facilities, & Lawn Extensions).

Table A
Right-of-Way Widths and Design/Posted Speeds

National Functional Classification	Act 51	Minimum Right-of-Way Width	Design/Posted Speed
Local	Local	66’	25 mph design, not generally posted
	Major		25 mph
Collector	Local		
	Major		
Minor Arterial	Major	Varies dependent on use	
Principal Arterial	Major		

5. Street Drainage Design: General

a) The street drainage design shall conform to the requirements of Article 4 (Stormwater) of these Standards and, for new construction and reconstruction of streets, shall conform to the City’s Public Streets Stormwater Management Guidelines.

b) All streets shall be designed to include 6-inch diameter, flexible, wrapped, perforated, PVC edge drains as indicated in Article 12 (Standard Details), SD-TD-5 (Typical Edge Drain Trench) of these Standards. Edge drains shall be connected to drainage structures and shall extend a minimum of 100 feet upgrade.

c) Additional edge drain may be required by the PSAA based on the topography of the area, existing water table or soil type(s), condition of the subgrade, or other factors that may affect the long-term stability of the pavement structure. The grade of the edge drain is to match the road grade, but in no case shall it be installed at a grade of less than 0.50% or at a depth of less than 3 feet as measured from the top of existing/proposed pavement.

6. Vertical Alignment

a) Longitudinal street grades shall meet the requirements of Table B of this Article.

b) The pavement's transverse crown line shall be centered in the cross-section or located along a longitudinal pavement joint (as directed by the Engineer) and shall meet the requirements of Table B of this Article.

Table B
Longitudinal Street and Transverse Crown Grades

Street Classification	**Minimum Longitudinal Grade**	**Preferred Longitudinal Max. Grade**	**Max. Longitudinal Grade for Special Conditions***	**Transverse Crown** (centered in cross section)
Minor Local and Local	1.0%	7.0%	8.0%	2.5%
Residential Collector	1.0%	5.0%	7.5%	2.5%
Commercial/Ind. Collector	1.0%	4.0%	7.0%	2.0%
Arterial	1.0%	4.0%	6.5%	2.0%
*Required approval of PSAA				

c) Vertical curves are required at all intersecting grades where the change in grade exceeds 1.0%.

d) The lengths of all vertical crest and sag curves shall meet the requirements of AASHTO.

e) Grades within a street intersection shall not exceed 3.0% for a distance of 100 feet from the intersection of the street centerlines.

f) The curb grades may be separated (from the longitudinal roadway centerline grade) as they approach an intersection to meet this requirement.

7. Horizontal Alignment

a) The use of superelevation of horizontal curves is not allowed unless required by unusual conditions and approved by the PSAA.

b) "Broken-back" curves (having a short tangent between two curves in the same direction) are not allowed. Rather a compound curve shall be used. In this compound curve, the radius of the flatter circular arc, R1, shall not be more than 1.5R2, where R2 is the sharper circular arc.

c) Tangents are required between all reverse horizontal curves. The minimum tangent length shall be defined by Table C of this Article for horizontal curves without superelevation.

d) The radius to the center of the inside lane of all horizontal curves (for multi-lane pavement sections), and tangent lengths between reverse horizontal curves, shall meet the minimum requirements per Table C of this Article. The curve radius may be measured to the centerline of roadway for two-lane roads. Radii are derived from the formula: $f = (V^2/15R)-0.01e$ where f = side friction factor(Fig. 3-4, AASHTO); V = design speed, mph; R = radius length, ft; e = crown (Table C is based on e = 2% and e = 2.5%). Minimum radii required are shown in Table C.

Table C **Horizontal Curve Radius and Tangent Minimum Lengths**			
Design Speed (mph)	**Crown**	**Min. Radius Length** (ft.) **to Center of Inside Lane**	**Minimum Tangent Length** (ft.)
25	2.5%	166	110
30	2.5%	266	132
35	2.5%	408	154
35	2.0%	418	154
40	2.0%	661	176
45	2.0%	892	198

8. Stopping Sight Distance

a) A continuous minimum stopping sight distance along the vertical and horizontal alignment of all streets shall be provided. Minimum distances for level streets and streets with downgrades or upgrades shall meet the requirements of Table D of this Article (based on Tables 3-1 and 3-2 of AASHTO). Design values for speeds or grades not shown in this table shall be calculated per AASHTO stopping sight distance standards.

Table D **Stopping Sight Distance**							
Design Speed (mph)	**Stopping Sight Distance** (Ft.)						
	Level to Less than 3%	Downgrades			Upgrades		
		3%	6%	9%	3%	6%	9%
25	155	158	156	173	147	143	140
30	200	205	215	227	200	184	179
35	250	257	271	287	237	229	222
40	305	315	333	354	289	278	269
45	360	378	400	427	344	331	320

b) This continuous line of vision shall be measured from a point 2.0 feet above the pavement (height of object) to assumed driver's eye height of 3.5 feet above the pavement.

c) There shall be no objects or structures located within this line of vision.

9. Intersection Sight Distance

a) At any uncontrolled intersection (no yield signs, stop signs, or traffic signals) an unobstructed approach sight triangle shall be provided in accordance with AASHTO (Approach Sight Triangles (Uncontrolled or Yield Controlled)).

b) For such uncontrolled intersections, the minimum length of each leg of the sight triangle shall be based on the design speed for each leg of the intersection. These minimum lengths shall be in accordance with Table E of this Article, based on AASHTO's *Length of Sight Triangle Leg—Case A, No Traffic Control*. Where the longitudinal grade along an intersection approach leg exceeds 3 % lengths provided in Table E shall be modified in accordance with AASHTO's *Adjustment Factors for Intersection Sight Distance Based on Approach Grade.*

Table E
Intersection Sight Distance Sight Triangle Leg Lengths

Design Speed (mph)	**Distance** (Ft.)
25	115
30	140
35	165
40	195

c) Where streets with two different classifications intersect and the lower classification street is stop controlled, the minimum stopping sight distance on the street with the lower classification shall be provided in accordance with AASHTO, Section 9.5.3.2 (Case B-Intersections with Stop Control on the Minor Road) and Tables 9-7 (Design Intersection Sight Distance-Case B1, Left Turn from Stop), Table 9-9 (Design Intersection Sight Distance-Case B2, Right Turn from Stop), and Table 9-11 (Design Intersection Sight Distance-Case B3, Crossing Maneuver).

d) Design intersection sight distance lengths for other intersection configurations or movements not addressed in preceding Sections I.B.9.a)-b) (Intersection Sight Distance) of this Article shall be in accordance with AASHTO, Section 9.53 (Intersection Control), as set forth for Cases C1 through G.

e) For skewed intersections, modifications to the sight distance parameters shall be as governed by AASHTO, (Effect of Skew).

f) The point of vision shall be located from the driver's eye position of the secondary street at a point 3.5 feet above the proposed street grade, to 3.5 feet above the major street grade at locations as depicted in AASHTO, Section 9.5 (Intersection Sight Distance).

g) Commercial and multi-family drive approaches shall meet decision sight distance requirements. Single-family drive approaches shall meet stopping sight distance requirements.

h) When developing intersections on streets with separated bike facilities cyclist sight triangles shall adhere to NACTO guidance.

10. Intersection Design

a) Street intersections shall be as near to a 90-degree angle as possible, but in no event less than 80 degrees.

b) Vertical road grades at an intersection shall comply with those specified in Section I.B.6. (Vertical Alignment) of this Article.

c) Intersections shall be designed such that the sight distances shall comply with those specified in Section I.B.9. (Intersection Sight Distance) of this Article.

d) Intersection curb radii shall be derived from the formula: $f = (V^2/15R)-0.01e$ where f = side friction factor(Fig. 3-4, AASHTO); V = design speed, mph; R = radius length, ft; e = crown (Table C is based on e = 2% and e = 2.5%). Design speed for intersection curb radii shall not exceed 15 mph.

e) At the discretion of the PSAA, truck/bus aprons may be allowed to achieve the turning speed while accommodating larger vehicles.

f) Intersection radii may be modified in accordance with NACTO where it can be demonstrated that the radius is adequate.

g) The minimum percent of grade around the intersection radii at the edge-of-metal shall be 1.0%.

h) At the intersection of a street with a street of a higher classification, the 2.0% crown of the major street is to be carried through the intersection.

i) The construction of low points within intersections shall be avoided to the greatest extent possible. If it is necessary to construct a low point within an intersection, it shall only be done after approval by the PSAA. Drainage structures shall be located at the point of curvature (PC). Additional structures within the curb line of the intersection may be permitted with the approval of the PSAA only where proper drainage for a curb ramp requires the addition.

j) A detail drawing of each intersection is to be submitted with the road plans. This plan shall provide adequate spot elevations to verify and ensure that the pavement and gutters will drain properly and will meet the requirements of these Standards.

11. Cul-de-sac Design

a) Cul-de-sacs shall be limited in length to 600 feet as measured along the center of the cul-de-sac from the right-of-way line extended of the cross street to the right-of-way line at the end of the cul-de-sac bulb.

b) At the bulb of the cul-de-sac, the right-of-way and pavement radii (to the edge of metal/pavement) shall be 60 feet and 45 feet respectively for streets with a 66-foot right-of-way at the stem, and 70 feet and 55 feet respectively for those with a 70-foot right-of-way at the stem.

c) A landscape island centered in the cul-de-sac bulb with a radius of 20 feet (to the back of the curb) will be allowed, provided that an established association (e.g. condominium association) will maintain the island through a recorded agreement approved by the City.

d) The pavement in the cul-de-sac bulb shall have a minimum pavement cross grade of 2.5%, and the curb around the bulb shall have a minimum grade of 1.0%.

e) A detail drawing of each cul-de-sac bulb is to be submitted with the road plans. Such plan shall provide adequate spot elevations to verify and ensure that the pavement and gutters will drain properly and will meet the requirements of these Standards.

12. Pavement Design

a) A copy of the pavement design calculations shall be submitted with the road plans for review and approval in accordance with Section I.A. (General) of this Article. Documentation justifying the reasons for selecting the parameters and values used to determine the pavement design are to be submitted along with the calculations and are subject to the approval of the PSAA.

b) The following minimum parameters are to be included in the submitted pavement design calculations:

(1) Design Life shall be 20 years.

(2) Original Serviceability Index (Pp) shall be 4.5 for all new street construction.

(3) Terminal Serviceability Index (Pt) shall be 2.0 for Minor Local, Local and Residential Collector streets and 2.5 for Arterial and Commercial/Industrial Collector streets.

(4) Reliability (R) shall have a default value of 90%. If a different value is warranted, justification for the proposed value shall be submitted for review and approval.

(5) Standard Deviation (So) shall have a default value of 0.45 for flexible (asphalt) pavements and 0.34 for rigid (concrete) pavements. If a different value is warranted, justification for the proposed value shall be submitted for review and approval.

(6) Drainage Coefficients are to be proposed based on the availability and location of edge drains and storm sewers. These drainage coefficients shall be subject to the approval of the PSAA.

(7) Traffic Estimate/Land Calculations shall be based on the following:

(a) Use a 20-year projection for traffic volume.

(b) Determine traffic in one direction only.

(c) Assume that 80% of truck traffic travels in the design lane.

(d) Determine total equivalent 18-kip axle loads in design lane (EAL) for the 20-year pavement design life.

(e) A traffic growth rate based on the WATS model and verified by the City.

(8) Effective Resilient Modulus of Existing Subsurface Soils (MR) (for flexible pavements) and Effective Modulus of Subgrade Reaction (k) (for rigid pavements) shall be determined by the Engineer based on the laboratory analysis of existing soil conditions. Soil conditions shall be determined from soil borings obtained along the proposed roadway at distance intervals and at depths sufficient to provide an accurate overall soils profile. Copies of these soil borings shall be submitted for review with the design calculations.

(9) Material Properties.

(a) For flexible pavements, a required structural number (SN) shall be determined using the equivalent single axle loading (ESAL), the effective resilient modulus (MR), the design serviceability loss (Po-Pt), the reliability (R), the overall standard deviation (So), and an accepted software program. The layer thicknesses used to achieve the required SN shall be determined using the drainage coefficients and layer coefficients, which have the following default values unless different values are warranted. If the design Engineer believes the use of different values are warranted, they shall submit in writing the reasons supporting the differing values for consideration by the City.

(i) Hot-Mix Asphalt (HMA) wearing course: 0.45

(ii) HMA base or leveling course: 0.35

(iii) Gravel: 0.14

(iv) Sand: 0.11

(b) For rigid pavement, a Modulus of Rupture (SC), Modulus of Elasticity (EC) and Load Transfer Coefficient (J) shall be determined for the proposed concrete pavement. Justification for the values shall be submitted in writing for review and approval.

(10) Flexible Pavement Minimum Thickness Requirements

(a) Minimum thicknesses for flexible pavement shall be per Table F of this Article.

Table F Flexible Pavement Minimum Thickness			
Street Classification	**Min. Asphalt Thickness**	**Min. Aggregate Base Thickness**	**Min. Sand Subbase Thickness**
Minor Local	4”	8”	8”
Local	4”	8”	8”
Residential Collector	4”	8”	8”
Commercial/Industrial Collector	6” *	8”	10”
Arterial	6” *	8”	10”
*Additional depth shall be as required per design calculations			

13. Utility Locations

    a) Utility locations for streets classified as Minor Local, Local, and Residential Collector streets shall, insofar as possible, conform to the standard locations shown in Article 12 (Standard Details), SD-GU-9 through SD-GU-11 of these Standards as appropriate for the specific right-of-way width.

    b) Utility locations for streets classified as Commercial/Industrial Collector or Arterial will be reviewed on an individual basis by the PSAA.

14. Concrete Curb and Gutter

    a) All new streets are to be designed with concrete curb and gutter.

    b) Concrete curb and gutter shall conform to Article 12 (Standard Details), SD-CG-1 through SD-CG-4 of these Standards based on the type applicable.

II. Materials Standards

A. General

1. All materials shall conform to the Michigan Department of Transportation Standard Specifications for Construction (hereafter MDOT Specifications), except as herein modified. Where MDOT-authored Special Provisions related to a specified MDOT Specifications Section have been issued, same shall be incorporated by reference.

B. Steel Reinforcement

1. Reinforcing steel shall conform to MDOT Specifications, Section 905 (Steel Reinforcement).

2. Welded steel wire fabric shall conform to MDOT Specifications, Section 905.

C. Structural Steel

1. Structural steel shall conform to MDOT Specifications, Section 906 (Structure Steel).

2. High-strength steel bolts, nuts, and washers for joining structural steel shall conform to MDOT Specifications, Section 906.

D. Miscellaneous Metal Products

1. Longitudinal and transverse tie bars for concrete pavement shall conform to MDOT Specifications, Section 914 (Joint and Waterproofing Materials).

2. Anchor bolts, nuts, washers, and all other related materials shall conform to MDOT Specifications, Section 908 (Miscellaneous Metal Products).

E. HMA Mixtures

1. HMA mixtures shall be provided and mixed in conformance with the requirements specified in MDOT Specifications, Section 501 (Plant Produced Hot Mix Asphalt).

2. Mixture and binder selection shall conform to MDOT Local Agency Programs Hot-Mix Asphalt Selection Guidelines with the exception that 4C is specifically prohibited and other listed Marshall design method mixtures shall also be prohibited unless specifically authorized by PSAA. All mixtures and binders and their use shall be subject to the approval of the PSAA.

F. Aggregate for HMA

1. Aggregate in Superpave HMA mixtures shall conform to MDOT Specifications, Section 902 (Aggregates) with the exceptions noted in Section II.F.3. of this Article.

2. Aggregate in Marshall HMA mixtures, where permitted by the PSAA pursuant to Section II.E.2. of this Article shall conform to MDOT Special Provision for Marshall Hot Mix Asphalt Mixture with the exceptions noted in Section II.F.3. of this Article.

3. Aggregate containing crushed concrete or furnace slag may not be used.

G. Asphaltic Materials for HMA

1. Asphalt binder shall conform to MDOT Specifications, Section 904 (Asphaltic Materials).

2. Where HMA, High Stress mixtures are shown on the plans, increase the high temperature binder by one grade and add the polymer.

H. Aggregate Base Course for HMA or Portland Cement Concrete Roadways

1. Dense-graded aggregate shall be MDOT Class 21AA or 22A in conformance with MDOT Specifications, Section 902 (Aggregates).

I. Subbase for HMA or Portland Cement Concrete Roadways

1. Subbase materials shall be granular materials, 2NS or Class II, in conformance with MDOT Specifications, Section 902 (Aggregates).

J. Embankment Materials

1. Embankment materials shall be granular materials, Class II or III, or cohesive soils that are free of frost-textured materials (sound earth) conforming to MDOT Specifications, Section 902 (Aggregates) or Section 205 (Roadway Earthwork) respectively.

2. Excavated material, if used as embankment material, shall consist of clay, sand, gravel, or other similar material, provided all material is free of cinders, ashes, refuse, vegetable or organic matter, boulders, rocks greater than 4 inches measured in any one direction, broken concrete or other matter which, in the PSAA's judgment, is unsuitable as fill material.

K. Riprap

1. Stone for riprap shall conform to MDOT Specifications, Section 916 (Erosion and Sedimentation Control Materials) except that broken concrete shall not be permitted.

L. Portland Cement Concrete Pavement and Curb and Gutter Mixtures

1. Portland cement concrete mixtures for roadways and curb and gutter shall be mixed in conformance with the requirements specified in MDOT Specifications, Section 1004 (Concrete Mixtures).

2. MDOT Grade 3500 concrete in conformance with MDOT Specifications, Section 1004 shall be utilized. MDOT Grade 3500HP concrete may be specified by PSAA where deemed appropriate.

3. MDOT Grade P-NC concrete in conformance with MDOT Specifications, Section 1006 (Patching, Repair, and Overlay Mixtures) may be required for concrete repairs or patches where high early strength is, at the direction of the PSAA, deemed necessary.

4. The maximum slump for MDOT Grades 3500 or P-NC concrete shall be 3 inches without the use of a mid-range water reducing admixture.

5. The maximum water-cement ratio by weight for Grades 3500 or P-NC concrete shall be 0.45.

M. Aggregate for Portland Cement Concrete Pavement and Curb and Gutter

1. Aggregate for mixtures shall conform to MDOT Specifications, Section 902 (Aggregates) with the exceptions noted in II.F.3. of this Article.

N. Cement for Portland Cement Concrete Pavement and Curb and Gutter

1. Portland cement shall be Type IL Portland Cement in conformance with MDOT Special Provision for Portland Cement (Type IL).

O. Concrete Curing Material for Portland Cement

1. Concrete curing material shall conform to MDOT Specifications, Section 903 (Admixtures and Curing Materials for Concrete). White curing compound shall be utilized.

P. Flowable Fill

1. Flowable Fill shall consist of one of the following mixes:

   a) Portland cement, fly ash, and water

   b) Portland cement, granular material, fly ash, and water

   c) Fly ash, granular material, and water

2. All flowable fill after having set up is intended to be removed by conventional mechanical excavation methods.

3. All materials to be used in flowable fill shall meet the requirement per Table G of this Article.

Table G
Acceptable Mixtures for Flowable Fill

Mixture	Ingredients	
FF Mix Number One: Cement Stabilized Fly Ash Mixture (Class F Fly Ash)	Portland Cement	100 lbs/yd³
	Fly Ash (Class F)	2000 lbs/yd³
	Water	Sufficient water to produce the desired flowability (approx. 80 gal/ yd³)
FF Mix Number Two: Controlled Density Fill Mixture (Class F Fly Ash)	Portland Cement	50 lbs/yd³
	Fly Ash (Class F)	500 lbs/yd³
	Granular Material	2600 lbs/yd³
	Water	Sufficient water to produce the desired flowability (approx. 50 gal/yd³)
FF Mix Number Three: Controlled Density Fill Mixture (Class C Fly Ash)	Fly Ash (Class C)	300 lbs/yd³
	Granular Material	2600 lbs/yd³
	Water	Sufficient water to produce the desired flowability (approx. 50 gal/yd³)