4-05.1 APPROACHES AND DRIVEWAYS. The location and design of approaches and driveways affect the safety and traffic handling capacity of the highway. Therefore, the location and design of each such feature receives careful consideration. The number of access points is held to a minimum with due consideration to the type of facility being designed, convenience to the highway user, and convenience of access to adjacent property. Each driveway and approach should be designed with appropriate width and radius which will permit entry of controlling design vehicle without encroachment on opposing traffic lanes.

4-05.1 (1) NUMBER. Direct access is not allowed to the thru lanes on freeways designed with full control of access. The number of access points is held to a practicable minimum on facilities designed with limited access right of way. On other facilities only the minimum number of access points necessary to provide convenient access to adjacent properties is allowed.

4-05.1 (2) DESIGN STANDARDS. Driveways are designed in accordance with the details on the standard plans. The grade controls given on the standard plans are adhered to if at all practicable. The department's Driveway Permit Manual defines driveway types and includes basic design criteria for each. The minimum desirable radii, surface type, and thickness for driveways are tabulated in Table 4-05.1.

TABLE 4-05.1
DRIVEWAY MINIMUM STANDARDS

TYPE APPROACH	MINIMUM RADIUS	MINIMUM SURFACE
Driveway Type I	3.0 m (10 ft)	100 mm (4") - Aggregate with 50 mm (2") A.C. or Bit. Pav't to radius point
Driveway Type II	9.0 - 15.0 m* (30 - 50 ft)	100 mm (4") - Aggregate with 50 mm (2") A.C. or Bit. Pav't to right of way line
Driveway Type III	3.0 - 12.0 m (10 - 40 ft)	100 mm (4") - Aggregate with 50 mm (2") A.C. or Bit. Pav't to right of way line
Driveway Type IV	15.0 m (50 ft)	150 mm (6") - Aggregate with 50 mm (2") A.C. or Bit. Pav't to right of way line
Driveway Type V	28.0 m (90 - 95 ft)	Est. by Design Division
Alley	1.5 - 3.0 m (5 - 10 ft)	100 mm (4") - Aggregate with 50 mm (2") A.C. or Bit. Pav't to right of way line

* Without signals

4-05.1 (3) COMMERCIAL DRIVEWAYS. Commercial driveways are designed in accordance with the details on the standard plans. The maximum width of commercial driveways measured at the radius point is 18.0 meters (60 feet). The width specified on the plans is the width measured normal to the centerline of the entrance. 100 millimeter (4 inch) barrier concrete or asphalt curb or concrete curb and gutter is specified for the delineation of commercial driveways and along the right of way line as necessary to restrict use of right of way area as indicated on the standard plans. Driveways are located relative to property line and to other driveways in accordance with the standard plans whenever possible.

4-05.1 (4) BREAK IN ACCESS. A standard 18.0 meter (60 feet) wide break in access will be provided for all driveways on limited access right of way projects. The driveway width shown on the plans will be the width appropriate for the type of development and traffic needs. Both driveway width and "break in access" width are shown in the plans.

4-05.1 (5) MAILBOX TURNOUTS AND SUPPORTS. Mailbox turnouts apply to resurfacing projects. Mailbox turnouts may be provided on resurfacing projects which include some earthwork, such as shaping shoulders. Consideration should be given to inclusion of this item where the finished shoulders are not of sufficient width to allow a vehicle to get off the traveled way.

Shoulder widths of less than 2.4 meters (8 feet) require special mailbox turnouts in accordance with the standard plans. When shoulders 2.4 meters (8 feet) and wider are provided, special mailbox turnouts will not be necessary.

When stabilization is not provided on shoulders, provide 100 millimeter (4 inch) of Type 1 or 2 aggregate with 50 millimeter (2 inch) Type IC asphaltic concrete or plant mix bituminous pavement surfacing for mailbox turnouts.

Use pipe only when required by restrictive right of way or extreme drainage condition.

AASHTO has prepared a guide for erecting mailboxes on highways which was approved as an informational guide by the executive committee of AASHTO on May 24, 1984. The guide states that a nominal 100 x 100 millimeters (4" x 4") square or 115 millimeter (4 $^1/_2$") diameter wood posts or 38 to 50 millimeter (1 $^1/_2$" to 2 ") standard steel or aluminum pipe posts, embedded no more than 600 millimeters (24 inches) into the ground, are the maximum strength supports which should be considered for mailboxes.

The following guidelines will apply for mailboxes encountered during the design of all resurfacing projects.

During the design stage of the project, any mailbox support which is noted to be in gross violation of the approved mailbox supports should be noted by location. Notice of these mailboxes should be sent to the local postmaster requesting their assistance in requiring the mail patron to change the mailbox support to comply with national standards and reduce the potential safety hazard. The design file should document the fact that such mailboxes were checked and further document the action taken through the local postmaster. The district construction engineer should be furnished copies of necessary correspondence for use after award of the contract.

4-05.2 CROSSOVERS. Crossovers are considered only at State Routes, county roads, and major streets. Details for crossovers are shown in the standard plans. Maintenance and emergency crossovers are constructed by district maintenance forces and are not considered in the design plans.

4-05.3 STATE ROUTES AND IMPORTANT ROADS AND STREETS. Highways are designed to ultimately provide for the safe, convenient and economical transportation of persons and goods. The success of such design is dependent upon proper planning, geometric design, and efficient traffic operations. It is the intent of this subsection to cover general requirements only. Variations required by location and local conditions will usually offer an infinite number of solutions for specially designed grade intersections.

4-05.3 (1) GEOMETRIC DESIGN. Designs for important side road intersections are based on a volume product. For volume products equal to or greater than 700,000 the design shown on Standard Plan 203.65 is used. For volume product intersections less than 700,000, see Standard Plans 203.62. The volume product is the product of Vm x Vc. Vm is the design ADT on the major approach (one direction volume for divided and both direction volume for 2-way). Vc is the design ADT on the minor approach.

Efficient traffic operation is dependent upon geometric design. It is desirable that the geometric design consider traffic signal control as a design criterion at all intersections where traffic conflicts are present. When this is not done and traffic signal control becomes necessary, the net result is usually that signals must often be poorly located with respect to driver vision, protected left turning movements disregarded, and other such necessary requirements for efficient traffic signal control compromised or forgotten.

Grades are designed in accordance with Subsection 4-04.2.

Schematic details for grade intersections are indicated on the strip map, along with traffic data, including turning movements. The strip map approval will constitute approval of the schematics of the intersections.

4-05.3 (1) (a) CAPACITY. The appropriate capacities for grade intersections without signals are given in Table 4-05.2. The capacities for signalized intersections are as follows: The practical capacity of each lane of a signal controlled approach is 1000 passenger cars per hour of green time per 3.0 meters (10 feet) of pavement width where conflicts with parking, turning movements, commercial vehicles, and pedestrians are at a minimum, and where no vehicles are required to wait more than one time cycle for right of way. This capacity is reduced one per cent for each one per cent of commercial vehicles and uncontrolled left turning movements, and one half of one per cent for each one per cent of right turning vehicles. The average time spacing for moving vehicles at signalized intersections is 2.1 seconds. The maximum traffic volume that can turn left or right from a 3.0 meter (10 feet) wide auxiliary lane in a 30-second phase with ten percent commercial vehicles present is 450 vph for a 60-second time cycle, 300 vph for a 90-second time cycle, and 225 vph for a 120-second time cycle. A two-lane approach for high volume turns will increase these capacities by about 50 percent. Turning movement phases longer than 30 seconds, except at Tee intersections, are not practical and are not used for design purposes. The foregoing volumes for turning vehicles should be used as a guide only. A more detailed capacity analysis should be made as outlined in the Highway Capacity Manual, to determine the exact needs and requirements for a signalized intersection.

TABLE 4-05.2
TRAFFIC CAPACITIES FOR GRADE
INTERSECTIONS WITHOUT SIGNALS
(Two-way Design Hourly Volumes)

2-Lane through Highway	400	500	600
Croassroad	250	200	100
4-Lane through Highway	1,000	1,500	2,000
Croassroad	100	50	25

4-05.3 (1) (b) ISLANDS. Islands are triangular or longitudinal. Triangular islands are generally used on the minor approach to an at-grade intersection; cross-overs for major side roads, state routes and major streets; signalized intersections; and on ramp terminals at the cross-road or streets at interchanges. Islands at ramp termini are used in accordance with Figure 4-06.3. Islands for at-grade intersections shall be in accordance with Standard Plan 203.65. Islands when required at cross-overs shall be in accordance with the standard plans. Where the highway shoulder is carried through the intersection, the island is placed at the edge of the shoulder. The side of a longitudinal island adjacent to through-traffic lanes is offset from the edge of the traffic lane by at least 0.6 meter (2 feet). The island may be offset a greater distance if necessary or desirable to eliminate a particular hazard.

The two primary types of islands used are as follows:

4-05.3 (1) (b) 1. DIVISIONAL ISLANDS. These normally are longitudinal islands used to divide opposing traffic and elsewhere to positively restrict encroachment thereon by vehicles. They are not less than 1.2 meters (4 feet) in width nor less than 3.6 meters (12 feet) , preferably 6.0 meters (20 feet), in length.

A divisional island nose is offset a minimum of 1.2 meters (4 feet) from the projected edge of the travel way of the cross road or street. Divisional islands are always constructed with barrier type curbs and basic lighting is provided to the extent necessary to illuminate the ends of such islands. Examples of divisional islands are (a) short bulb-type median islands used to provide protected left turn movements, (b) all islands between opposing traffic streams, and (c) all islands established for the purpose of locating traffic signal poles or lighting poles.

4-05.3 (1) (b) 1. CHANNELIZING ISLANDS. These are islands used to guide and direct same direction traffic streams or diverging traffic streams. Channelizing islands may consist of painted areas, flush sodded areas, or raised islands. The islands are a minimum of 7.0 square meters (75 square feet) in area or about 3.0 meters (10 feet) on a side after rounding. Where raised channelizing islands are used, they are always constructed with mountable type curbs. Channelizing islands are not lighted except when lighting is justified by other warrants. Examples of channelizing islands are those established for (a) guiding parallel or diverging traffic streams, (b) locating small signs, (c) providing pedestrian refuge, and (d) reducing large paved areas at intersections. When questions arise concerning the classification of a particular island which is border line with respect to divisional or channelizing, the particular island should be classed channelizing to preclude the lighting provision. In those cases where it is apparent that traffic signals will be installed within a reasonable time after construction at the intersection or interchange the islands should be designed as divisional and lighted initially. Additional information about islands is given in Chapter IX of the AASHTO Green Book.

4-05.3 (1) (c) AUXILIARY LANES. These are lanes provided at an intersection to allow turning vehicles to slow and/or store out of the thru traffic lanes. It is desirable to provide these lanes at all signalized intersections if practical, even though the turning movement is not separately signal controlled, as the auxiliary lane will tend to reduce accidents, improve intersection capacity, and allow for the most efficient methods of controlling traffic.

4-05.3 (1) (c) 1. LEFT TURN LANES. Left turn lanes are considered at street or road intersections where the number of left-turning vehicles is 100 vph or more during the peak hour. Where the peak hour left-turning traffic exceeds 300 vph, provision for two-lane left turns is considered. Left-turn facilities should be considered on roadways where traffic volumes are high enough or safety considerations are sufficient to warrant them. Table IX-15 of the AASHTO Green Book should be used as a guide to traffic volumes where left-turn facilities should be considered. Traffic volumes shown in Table IX-15 are vehicles per hour (vph). Left turn lane should also be considered at intersections where traffic volumes do not warrant but are required because of poor visibility or accident records indicate a need for safety considerations. Left turn lanes are 3.0 meters (10 feet) minimum in width plus additional width required for striping for flush medians or for curb clearances of barrier curbs for raised medians. Left turn lanes for 50 or 70 km/h (30 or 40 mph) design are developed according to the minimum transitions shown on Figure 4-05.1 (Raised Median) and are constructed using barrier curbs and are lighted to the extent necessary to illuminate the ends. Left turn lanes for 80 or 100 km/h (50 or 60 mph) design are developed according to the minimum transitions shown on Figure 4-05.2 (Flush Median). Left turn lanes developed from continuous medians are constructed with barrier curbs for at least the length of the left turn storage with the barrier end lighted. As a guide, 60 200 feet) meters is the desirable minimum length for left-turn lanes. An additional length of a constant 3.0 meters (10 feet) minimum width lane is provided and may be required for storage. Data for establishing the storage length is discussed later in this section.

The use of a divisional island at an intersection to separate the left turning traffic from same direction thru traffic may be desirable, particularly where opposing traffic is separated by a wide median. This island will make a left turn from an auxiliary left turn lane mandatory and requires lane control signing.

4-05.3 (1) (c) 2. RIGHT TURN LANES. Warrants for right turn lanes are the same as those indicated above for left turn lanes. At signal controlled intersections, these lanes are separated, where practical, from same direction thru traffic by a channelizing island to make the right turn mandatory.

An auxiliary right turn lane at signal controlled intersections is provided primarily for storage of right turning vehicles and not for deceleration purposes. To prevent thru vehicles from being falsely led into the auxiliary right turn lane, an abrupt taper is used at the beginning of the lane. At locations where it is either impractical or not warranted to provide an auxiliary right turn lane, a channelizing island will reduce right turning maneuver conflicts with thru traffic. This movement may be made a "yielding" maneuver. However, a few straight thru vehicles stopped for a red indication in the right lane will block the right turn and conversely, a few right turning vehicles stopped while waiting for a gap in the cross street traffic will block the right lane for thru vehicle storage.

4-05.3 (1) (c) 3. EXACT LENGTH OF AUXILIARY LANES. The exact length of a full width auxiliary lane necessary for storage of vehicles desiring to turn left or right at signal controlled intersections is determined on the basis of the maximum possible total time cycle, peak hour traffic volume, and average storage length required per vehicle.

The exact length necessary is calculated by multiplying the average length required per vehicle (both trucks and cars) times the number of vehicles arriving per time cycle in the peak hour and is determined by the formula:

$$L = \frac{(\%\ PC \times 25) + (\%\ TK \times 40)}{100} \times \frac{(vph) \times (cl)}{3600} \times 0.3048$$

(USE 0.3048 FOR METRIC ONLY)

Where

L = exact length in meters (feet)
vph = vehicles per hour (design peak hour)
cl = cycle length in seconds
PC = passenger cars, pickup and panel trucks
TK = single unit or combination tractor trailer trucks and buses
% = percent as a whole number

4-05.3 (1) (c) 4. REQUIRED STORAGE LENGTH. The required storage length for use in design is 1.5 times the calculated exact storage for major streets and 2.0 times the calculated exact storage for freeway off-ramps. As a guide a 60 meter (200 feet) minimum storage length is desirable.

The calculated required length may be varied, when necessary, to provide a practical design consistent with capacity limiting features of the street approaches beyond the limits of the proposed improvement or with the unavoidable conflicts with other traffic movements on the same approach.

4-05.4 TURNING RADII AND ROADWAY WIDTHS

4-05.4 (1) TURNING RADII. Minimum design vehicle turning radii are shown in Table 4-05.3. These radii are satisfactory as minimum design where turning speeds of 15 km/h (10 mph) or less are appropriate at intersections. The radii for turning movements at urban street intersections can be less where the extra pavement width serves to increase the useable radius. When curbs are used, it is desirable to use flatter curves than those in the minimum edge-of-pavement designs.

The choice of minimum design for intersection radii is given in Chapter IX of the AASHTO Green Book. This identifies the turning radii used for the design of various roadway facilities and the type of design vehicle to use as the control.

The geometric radii for ramp terminals on the interstate and primary system will need to provide for the turning movement of the maximum semitrailer that can legally operate in Missouri. The trailer for this unit is 16.154 meters (53 feet) in length. Offtracking templates for this unit and others are furnished by the Design Division.

Turning radii for left turns for signal controlled intersections require 15.0 meters (50 feet) minimum to the inside edge of the turning path for efficient operation. Turning radii for channelized right turns at signal controlled intersections are 15.0 meter (50 feet) minimum. It is preferable to use 25 to 45 meter (75 to 150 feet) turning radii when right of way limits permit.

TABLE 4-05.3
DESIGN VEHICLE TURNING RADII

	MINIMUM SIMPLE TURNING RADIUS	
DESIGN VEHICLE	**m**	**ft**
Passenger Car (P)	9	25 or 30
Truck (SU)	15	50 or 55
Semitrailer (WB-15)	23	75

A simple curve with taper combinations is used for the design of channelized right turns to provide for the turning movement of semitrailer combinations. This is the preferred design because of its ease in layout for construction. Minimum edge-of-pavement designs for a simple curve with taper combinations are shown in Chapter IX of the AASHTO Green Book, for various type vehicles and skews of intersecting roads.

4-05.4 (2) ROADWAY WIDTHS. Pavement widths of turning roadways are controlled by the volumes of turning traffic and the types of vehicles to be accommodated. Where lane widths of channelized right turn lanes exceed 6.0 meters (20 feet) in width, lane delineation with painted lane markings are appropriate to restrict the turning movement operation to one lane use. Vehicles with wider offtracking wheel paths can still use the extra paved width to negotiate the turn. Required roadway widths for the vehicle offtracking can be determined by templates furnished from the Design Division and Chapter III of the AASHTO Green Book. An additional 0.3 meter (1 foot) clearance outside the maximum wheel offtracking along each side is provided for the turning roadway width.

4-05.4 (2) (a) LANE WIDTHS. At signal controlled intersections where existing street widths determine the lane use for various traffic movements, lane widths 3.0 to 3.9 meters (10 to 13 feet) are used, with widths of 3.3 to 3.9 meters (11 to 13 feet) desirable for safety and efficiency of operation.

4-05.4 (2) (b) INTERCHANGE OFF RAMPS. Off-ramps into signalized intersections are a minimum of 7.2 meters (24 feet) in width at the intersection when construction peak hour volumes are 60 vph or greater, or the design peak hour volume is from 90 to 120 vph or greater, in order to separately channel, store, and control right and left turning movements. The total length of 7.2 meters (24 feet) or divided pavement required is determined by the storage length required for the heavier of the two movements.

4-05.5 SIGHT DISTANCE. The minimum sight distance at all grade intersections, entrances, and crossovers, measured along the centerline of the main road, is equal to twice the stopping sight distance based on the design speed of the main road. This distance is based on a 1070 millimeter (3.5 foot) height of eye and 150 millimeter (0.5 foot) height of object, if at all practicable. In special cases, where this is not practicable, the distance is based on a 1070 millimeter (3.5 foot) height of eye and 1300 millimeter (4.25 foot) height of object. The minimum sight distance at all grade intersections measured along the minor road, is the stopping sight distance based on the design speed of the minor road. Exceptions are sometimes necessary where the minor road is being improved to intersect a more important road. Where the more important road is being improved, the minor road is located or improved as required to obtain the required sight distance. If the design speed of the minor road is not known, a design speed of 50 km/h (30 mph) is used. Grades are planned and access points are located as required to provide the required sight distance. Minimum sight distance requirements are tabulated in Table 4-05.4. The values tabulated are exceeded where practicable. These sight distance requirements insure that intersections and access points are visible to approaching traffic.

TABLE 4-05.4
MINIMUM SIGHT DISTANCE AT INTERSECTIONS

DESIGN SPEED (km/h)	ALONG MAIN ROAD 1070 mm - 150 mm 2 x S.S.D. (m)	ALONG MINOR ROAD 1070 mm - 150 mm S.S.D. (m)	"d" (m)
50	120 - 140	60 - 70	40
60	160 - 180	80 - 90	50
70	200 - 240	100 - 120	60
80	240 - 280	120 - 140	65
90	280 - 340	140 - 170	75
100	320 - 420	160 - 210	85
110	360 - 500	180 - 250	90
120	420 - 580	210 - 290	100

DESIGN SPEED (mph)	ALONG MAIN ROAD 3.5' x 0.5' 2 x S.S.D. (ft.)	ALONG MINOR ROAD 3.5' x 0.5' S.S.D. (ft.)	"d" (ft.)
30	400	200	160
35	450-500	225-250	160
40	550-650	275-325	185
45	650-800	325-400	200
50	800-950	400-475	220
60	1050-1300	525-650	260
70	1250-1700	625-850	310

A triangle of right of way is acquired for required sight distance and visibility at all state route and local road intersections, except where the normal right of way will provide the equivalent of the triangle of right of way. The triangle is graded to the elevation of shoulder point to shoulder point of intersecting roads, to provide the sight distance when the intersection is in a cut. The backslope is graded to the normal cut slope used on the project for the main roadway. Limited access right of way at intersections for otherwise non-limited access routes is provided at all state routes and side roads intersecting state routes which carry over 1,700 design ADT. See Section 4-02 for further details.

The dimensions for the additional triangle of right of way, where required, are determined by connecting points on the centerline of the intersected roads a distance "d" from the point of intersection, as tabulated in Table 4-05.4. Where grading is required to provide sight distance, additional right of way may be required to provide room for the grading. The design speed of each intersecting road is used to determine "d" in Table 4-05.4. For side road approaches where the design speed is unknown, an assumed design speed of 50 km/h (30 mph) is used. The right of way is dimensioned in 1.0 meter (5 feet) increments by scaling.

4-05.6 **SKEWS.** The skew of at-grade intersections and entrances is held at or below 20 degrees, if practical.

4-05.7 **CROSSROAD DESIGN CRITERIA.** Crossroads are sometimes reconstructed some distance beyond normal intersection limits because of design controls or for the construction of grade separations or interchanges. In such cases, the reconstruction is planned to meet basic design criteria based on the functional classification and design traffic on the crossroad whether the crossroad is a state route or not. On crossroads not part of the state highway system it is the policy to maintain roads being improved with a state highway project to within the limits of the "normal" right of way. Normal right of way includes sight distance right of way purchased at public road approaches.

4-05.8 PLANS. The plans show complete details for all intersections, approaches, and crossovers not detailed on standard plans. The plans include quantities for grading, drainage, and surfacing. The plans also show the station at right angles from the main roadway or outer roadway to the intersection of the right of way line with the centerline of all driveways as illustrated in Section 4-10. In most instances, unless critical, this station need not be computed but may be scaled.