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DESIGN CRITERIA FOR SPECIAL STREET COMPONENTS AND PROJECTS (E 600)

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In general, the design criteria and policies previously presented are applicable to the special street components and projects that are discussed in this chapter. However, since certain additional considerations must be given to these special street components or types of projects, their separate treatment is warranted.

**E 610 ALLEYS**

The discussion of alleys is divided into two parts. One deals with the desirable design criteria to be used in new subdivisions or undeveloped areas to be improved; the other covers the absolute minimum standards that may have to be used in connection with the improvement of existing alleys abutting existing improvements.

The use of design criteria as presented in this section should be confined within the maximum and minimum limits as specified for the various geometric and structural components of the alley. The use of absolute maximum and minimum design criteria or criteria not indicated as City standards may be permitted at the discretion of the Division or District Engineer. It is suggested that the designer become familiar with those portions of Section E 020B, *Standard Specifications, 1970 Edition*, that deal with alley construction practices, as well as Figures E 113, Standard Street Dimensions; E 431.1, Types of Curb and Gutter; and E 616.1B, Alley Intersections.

**ALLEY ALIGNMENTS**

In general, most alleys should be aligned as indicated hereon, either parallel to or concentric with the street property lines.

Figure E 611
E 611 LOCATION

Provisions should be made for the location of alleys in the rear of all residential lots fronting on major and secondary highways. They should also be included in new subdivisions where commercial or industrial zoning use is indicated, as per Ordinance No. 122,064, more commonly known as the “Subdivision Ordinance”, and Ordinance No. 122,312, the “Lot-Split Ordinance”.

Figure E 611 shows a typical alley layout with a complete traffic circulatory system within a given block, where vehicles need not enter directly from an alley into a primary or secondary highway. Also, refer to the discussion of alleys in Section E 262, Access Control, and Section E 451, Block Corner Property Lines. (See Figure E 611, on preceding page.)

E 612 ALIGNMENT

As can be observed from Figure E 611, alleys are aligned parallel to or concentric with the street property lines. Most alley alignments are arranged either singly or in the form of an intersecting “T” or “H”. In some very old subdivisions, street and alley alignments merely followed the random pattern of land development in use at that time. This policy resulted in many streets and alleys with sharp angle points, tapered widths, and abrupt jogs in the alignment. Although the streets, in most cases, have since been improved and realigned to modern standards, the existing alley alignments remain substandard. Frequently, corner cut-offs, which would facilitate vehicular turning movements, were not provided at the intersections of two alleys. Also, failure to make turn-around provisions resulted in many dead-end alleys.

The City’s policy in regard to improving these alley alignments is as follows:

1. Angle points and abrupt alignment changes are not permitted in new developments and are corrected in existing alley alignments.

2. Where two alleys intersect, a triangular corner cut-off of not less than 10 feet along each alley property line should be provided.

3. In existing alleys where no corner cut-offs have been provided, cut-offs of less than 10 feet may be acceptable where existing improvements limit the space available.

Where it is economically feasible to do so, all existing substandard alley alignments should be corrected.

E 613 WIDTHS

Ordinance No. 122,064, the “Subdivision Ordinance”, specifies that all alleys in new subdivisions should be 20 feet in width and alleys abutting industrial zoning 30 feet in width.

A design investigation should also be made for the widening of substandard width existing alleys. If it is not economically feasible to widen these alleys to standard widths, any lesser degree of widening that is practical should be considered.

E 614 ALLEY TERMINATION (DEAD-END AND CUL-DE-SAC ALLEYS)

Although it is usually desirable to locate alleys in such a manner that both ends of the alley are connected either to streets or to other alleys, it is not always feasible. In hillside or mountainous terrain, the connections may be impractical because of economic considerations. Large cuts or fills may necessitate dead-ending the alley at some appropriate location to keep the grading to a minimum. Other alleys may be cut off as a result of freeway construction or other projects. In new subdivisions, or in older existing alleys, it may be impractical to extend an alley through to the next street. This is usually because of extensive existing improvements in the logical path of alley prolongation.

Provisions must be made for a vehicular turning area where alleys dead-end. Figure E 113, Standard Street Dimensions, depicts the standard and minimum turning areas. Where these alleys are substandard width and cannot be widened, some modified form of equivalent turning area must be provided.

E 615 CURB RETURN RADII AT STREET INTERSECTIONS

An alley return is that portion of the curb which begins at the BCR on the intersecting street and ends at the ECR, the intersection of the property lines of the street and alley. See Figure E 616.1B. The normal curb return radius is 5 feet for an alley intersecting a street. In areas zoned for industry, commerce, or multiple residences, or in
narrow streets, the vehicular turning movements should be facilitated by increasing the alley return radii. The curb return radius may be increased from 5 feet to any radius up to 10 feet, provided it does not encroach onto private property.

Where existing improvements such as utility poles, fire hydrants, or other appurtenances interfere with the construction of a 5-foot-radius curb return, they should be moved. However, if existing facilities require costly remodeling or removals, a smaller curb return radius may be used to avoid incurring excessive costs. In any case, any variations from the standard 5-foot curb return radius are subject to the approval of the District or Division Engineer.

E 616. GRADE DETERMINATION

The grade determination of alleys differs from that of streets in several respects. One reason is that the maximum speed limit for alleys is generally 15 miles per hour. This speed is considerably lower than that of most streets and thus permits the lowering of design standards in several directions. For example, the sight distance and length of vertical curves rarely become a factor. However, a length of less than 50 feet for either sight distances or vertical curves should not be used. Another important difference is that streets have a border area and provide a buffer zone between the street grade and adjacent existing private improvements. This space permits a certain latitude in establishing a street grade. The lack of a buffer area does not usually create a problem in establishing a pavement grade for alleys in new subdivisions or for existing alleys in which adjacent property is unimproved. However, it often creates design problems in existing alleys where the existing improvements abut the alley property line and pavement. This difference between alley and street grade design criteria will become evident as the alley grade determination procedures are outlined.

E 616.1. Grade Determination Procedure: In discussing the procedure outlined for the alley grade determination of existing unimproved alleys with the adjacent property developed, several factors should be considered. For example, most of the existing alleys have had an official grade established but in some instances were never improved. Or it may be found that the curb returns, sidewalk, and pavement at the intersection of the alley and the street have been previously constructed.

It may be evident from a field inspection that some of the existing improvements abutting the alley were constructed without regard to the existing or future established alley grade. In any case, a complete set of field notes (survey) should be obtained. If the existing field notes are five years old or older, or if there is any reason to believe that existing conditions are sufficiently changed, new field work should be ordered. This information is plotted and the official grade superimposed on the existing profile and cross-sections to determine whether all, part, or none of the established grade should be used. Wherever possible, the official grade should be used joining those intersections that were previously constructed. If this requires excessive removals of existing abutting improvements or results in substandard design, establishing a new grade may be more practical. Where the alley intersections have previously been constructed, it may be even more economical to remove all or part of these intersections and reconstitute them to the new grade. Additional criteria for removals are covered in Section E 671.

In the above discussion it was indicated that the designer's prime concern is to meet existing improvements in existing alleys without sacrificing the City's design standards. To meet these standards for the existing alleys, the following procedure for establishing the grades in new unimproved alleys with undeveloped abutting property should be adhered to as closely as possible.

Referring to Figure E 616.1A, pick off or calculate the flow line elevations at the PI's at both intersections from plotted profiles of the existing or proposed flow line grades of the intersecting streets. The PI refers to the point of intersection of the flow line of the street and the alley property line (P.L.) produced. Next, add the height of curb at the intersection (assumed to be 8 inches, or 0.67 foot) to each calculated flow line (FL) elevation. This determines the theoretical top of curb (TC) elevation at the PI. Next, the product of the normal sidewalk slope (2.4 percent) and the distance between the curb face (CF) on the street side and the street property line (border distance) is added to the theoretical TC elevation. This is the design
E 616.11 Maximum and Minimum Longitudinal Grades: The design standards presented here are for use for all alley design. However, absolute minimum design standards are also submitted which may be used, at the discretion of the Division or District Engineer, to meet existing improvements abutting existing unimproved alleys.

E 616.111 Maximum Grades: The maximum allowable longitudinal grade permitted is 15 percent. In steep hillside areas where the existing grades exceed the maximum allowable, the difference in elevation between both ends of the alley or section of the alley must be reduced. This should be done by grading, providing smooth vertical curves to connect sharp grade breaks, acceptable crossfall for the transverse sections, and adequate drainage.

E 616.112 Minimum Grades: An economic study should be made of the alternate designs for alleys in flat areas. Consideration should be given to all the factors, such as removal and reconstruction costs, property damage, easements, and storm drain construction costs. The most economical method that provides adequate drainage should be chosen.

There should be sufficient difference in the prevailing elevations between both ends or flat sections of the alley to permit longitudinal drainage. The minimum rate of longitudinal grade permitted is 0.200 percent. In flat terrain where there is insufficient "fall" and where existing improvements prevent the development of this minimum grade, there are several methods by which drainage may be achieved. Where necessary, these methods permit the longitudinal grades of the alley property lines to be reduced to 0.000 percent, provided a longitudinal gutter grade of at least 0.200 percent and a minimum V cross-section are achieved.

Probably the most economical method is to vary the depth of the alley V cross-section from a minimum V depth at the high end to a maximum V depth at the low end of the alley. See Section E 617 for maximum and minimum Vs. This variation in V depth will increase the rate of grade of the concrete gutter or concrete pavement flow line. If this method does not provide the minimum grade and if the amount of available "fall" is limited by a small difference of elevations of the previously paved alley intersections, the intersection pavements, curb returns, and abutting sidewalks
may have to be removed. The intersections will then have to be redesigned to increase the elevation difference between both ends of the alley. When the intersections are raised or lowered, the property line grades approaching the intersections have to be raised or lowered. This grade change may prevent meeting the abutting existing improvements. If meeting these improvements is critical, the method of only slightly lowering the original grade may have to be combined with the above method of varying the depth of the V cross-section.

Other suggested methods of getting at least a minimum grade for drainage are as follows: Referring to the typical profile of the proposed alley grades in areas of flat or level terrain in Figure E 616.112(A), below, a high point is created in the alley to permit drainage in both directions. The high point should be located at such an elevation and location that a minimum rate of grade of 0.200 percent is developed. If water is draining from adjoining property into the alley, the location of the high point should not block this drainage.

If this method is not satisfactory, a sump is created and subsurface drainage provided, as shown on Figure E 616.112(B), below. The elevation of the pavement surface at the sump should be low enough to provide at least a minimum longitudinal grade of 0.200 percent. In locating the low point there are several important points to consider. Care should be taken to meet existing improvements to avoid undermining buildings, walls, etc. There should be a consultation with a representative of the Storm Drain Design Division or the Storm Drain Section of the District to ascertain the feasibility of making a connection from

![Typical Alley Profiles](image-url)
the proposed sump catch basin to an existing or a new storm drain facility. This may include contact with adjoining property owners to determine their attitude toward the City's acquisition of a storm drain easement through their property, should one be needed.

Referring to Figure E 616.112(C), below, another possibility is reversing the flow. This reversal is done by sloping the proposed grade connecting the two alley intersections in the opposite direction to the slope of the existing terrain. In existing alleys with abutting improvements, this method would be practical only if the cut or fill required to reverse the flow would not excessively damage existing improvements.

E 616.12 Grades for Driveway Encroachments at Alley Intersections: Where existing driveways or driveways to be constructed encroach in existing or proposed alley intersection curb returns, and where the driveway relocation is not feasible, the curb returns should be depressed to a 0-inch curb face. A transition is provided from the 0-inch curb face to a 1-inch curb face where the curb return merges into the driveway curb depression, assuming that the driveway curb depression has a 1-inch curb face. See Figure E 616.1B, Plate IV.

E 617 ALLEY CROSS-SECTIONS

The criteria used for the design of geometric and structural cross-sections will be treated in the following subsections. Reference is also made to Figures E 113, Standard Street Dimensions; E 431.1, Types of Curbs and Gutters; E 616.1A; and E 616.1B.

E 617.1 Alley Construction: Figure E 617.1, below, shows the standard geometric cross-section to be used for alley construction. Figure E 617A shows the standard transverse slopes, the maximum and minimum slopes, and the absolute maximum slopes used to form the V section for various widths of alleys under different conditions. These slopes are measured from the centerline of the gutter to the outer edges of the pavement at each property line.

In general, it is desirable to have the property lines level with each other and to use a standard V of 0.25 foot. The tabulations furnished on Figure E 617A and the sections on Figure E 617B are to serve as a guide. Where circumstances dictate other criteria to be used, the minimum V may have to be increased and the maximum V decreased.

Often, it will be found that this standard alley cross-section is not flexible enough to be used under all conditions. For example, the design of an existing unimproved alley with abutting improvements on a sidehill location is often characterized by a lopsided V section because of the large amount of crossfall that is introduced. It may be found that the modified cross-sections shown on Figure E 617B are more adaptable to this type of design. These modified cross-sections may be used either throughout the entire alley length or only at critical areas.

Before determining which section is applicable, consideration must be given to the amount of crossfall, drainage control, and grading; the need for alley access from abutting property; and the construction costs. For example, Figure E 617A shows, for an AC paved alley of 15 feet or less with a gutter offset of more than 5 feet, a minimum V depth of 0.17 foot. The Storm Drain Design Division or the Storm Drain Section of the District should be consulted for a specific location to see whether this minimum V is adequate to handle the anticipated drainage. Also, since some of the adjacent property may or may not be improved, and since it is not always apparent where access may be required, contact with the property owners in the preliminary design stage is strongly recommended. When the Division or District Engineer has been apprised of the circumstances requiring the use of sections, particularly those which may deny access, and has given his approval, these sections or any other suitable sections may be used.

These modified sections permit the development in the design of greater amounts of crossfall than the standard section and thus reduce the grading quantities involved and help meet existing improvements. In introducing large amounts of cross-
fall into the design, it may be necessary, in order not to exceed the maximum transverse slopes, to offset the gutter as shown on Figure E 617B, Plates II through VI. However, in offsetting the gutter, the water-carrying capacity of the alley is materially reduced, due to the elevation of the pavement at the lower property line in relation to the gutter centerline elevation. To increase the capacity, the lower property line elevation is compensated for by increasing the required minimum V depth as shown in the tabulation on Figure E 617A.

The sections on Figure E 617B show a curb or retaining wall used on the high side to reduce the amount of crossfall where vehicular access is not needed. The curb height of 4 to 6 inches is used where pedestrian access may be required. Concrete retaining walls may also be used on the low side both to reduce the crossfall and to increase the water-carrying capacity. Asphalt concrete berm is used on Plate V on the low side, with a maximum height of 0.50 foot to warp to join existing abutting pavement, sidewalk, driveways, etc. See Section E 618. A minimum height of AC berm of 0.33 foot is required to provide a minimum water-carrying capacity.

In narrow alleys paved with concrete, the outer edges of the concrete should not be warped as much as in the case of alleys paved with asphalt. Therefore, since greater flexibility is required to meet existing improvements, a greater percentage of cross-slope may be used. In addition, in narrow alleys 15 feet or less in width, the effective width of the alley is usually reduced owing to the placement of utility poles, encroaching fences, walls, structures, etc. Therefore, it is assumed that two vehicles would not attempt to pass each other simultaneously. However, in alleys more than 15 feet in width, the tops of two vehicles could make contact in attempting to pass. This is because each vehicle is tilted toward the other because of the cross-slope of each side of the alley section. This accounts for the greater percentage of cross-slope permitted (if needed) in narrow alleys.

It is also presumed that alleys more than 20 feet wide are constructed in industrial areas and are subject to use by maximum height vehicles. These vehicles may attempt passing maneuvers in the alley. Because of the greater encroachment of the vehicular paths of maximum-height vehicles, the maximum permitted percentage of cross-slope is further reduced.

![STANDARD ALLEY CROSS-SECTION](image)
E 617.11 Warped Alley Sections: Where deemed necessary by the designer, or when requested by the property owner whose property is affected, the alley surface may be warped to meet existing pavement, such as parking lots, driveways, housewalks, etc. The alley surface warping is done in the area where the existing pavement on private property is 6 inches or less above the alley pavement grade. The warped surface may not extend more than 18 inches into the alley. When existing pavement does not immediately abut the alley or is higher than 6 inches above the alley grade, and where the property owner does not wish to grant a right of entry for work to be done on private property, the alley pavement is not warped.

When alleys paved with concrete require warping to meet existing abutting pavement, the concrete may be warped up to a maximum of 0.2 foot. Asphalt concrete pavement is superimposed on the concrete where the warp is more than 0.2 foot. The reason the concrete should not be warped more fully is that the asphalt concrete, being temporary, can be more readily removed if the existing abutting pavement need no longer be joined. Joining abutting pavement becomes unnecessary where, due to deterioration, obsolescence, etc., older buildings and abutting paving surfaces are likely to be removed within a short time after the completion of the alley improvement. Experience has shown that removing abutting improvements and leaving an exposed permanent excess warp is undesirable and may also be hazardous.

Figure E 617.11, Plate I, shows a typical warped alley cross-section. In the example shown, it is assumed that at the vicinity where the alley pavement is to join the existing improvements, the alley grade was raised as high as possible and a smooth longitudinal grade provided without impairing the longitudinal drainage. In addition, a 10-percent maximum transverse slope is used for the V section. However, the proposed alley pavement at the property line remains below the level of the abutting pavement. Since the difference in elevation is 6 inches or less, the alley pavement may be warped as shown on the right side of the section.

Where the existing abutting pavement is higher than 6 inches above the alley pavement, or where the pavement is close to but does not abut the alley, as is shown on the left side of the section, work is required on private property. If the property owner so desires, the work may be done by following the procedures outlined in Subsection E 054.22A, Right of Entry, and in Chapter E 800, Procedural Steps for Proposed Improvement, for acquisition of a right of entry to construct pavement. All or part of the existing pavement may have to be removed and a smooth grade to the join provided.

A warped alley section 6 inches in height and extending laterally 18 inches into the alley can prove a substantial obstacle to a moving vehicle. Figure E 617.11, Plate II, is an elevation view and shows a transitional section provided for the purpose of lessening the effects of vehicular impact. The transition section should be a minimum of 1.5 feet in length for a 0-inch warped alley surface, or 5 feet minimum for berms, curbs, and retaining walls from 6 inches to 18 inches high. A transition for walls above this height is unnecessary, as it is reasonable to assume that higher walls would be readily seen and avoided by drivers. If the alley warp is less than 6 inches, the transitional length may be proportionately less.

Figure E 617.11, Plate III, is a plan view showing the transitional section connecting the normal alley section to the fully warped alley section.

E 617.12 Longitudinal Gutter Offsets from Alley Centerline: The centerline of the longitudinal gutter should normally be located on the alley centerline. As previously indicated, in order to keep the V slopes within the prescribed limits and to aid in meeting existing excessive crossfall, it may be necessary to offset the longitudinal gutter from the alley centerline. In addition, since the gutters normally carry the dry weather flow, the gutters may be offset for ease of access and for keeping dry during maintenance or servicing in manholes located in alleys.

If only a short section of gutter requires offsetting because of a local crossfall condition or a manhole, a gutter transition should be provided. The offset position is maintained for the minimum length necessary to accommodate the crossfall or bypass the manhole. Referring to Figure E 617.12, below, the gutter is then either transitioned back to the centerline as shown on Plate A, or if there is justification (such as additional manholes) for continuing the offset, it may be done as on Plate B.
In determining the amount of offset to use, consideration should be given to the construction problems that may be created by a gutter offset too close to the property line. The smallest width roller for pavement compaction is 3 feet. If the width of asphalt concrete between the outer edge of gutter and the inner edge of header board is less than 3 feet, the construction contractor may be forced to use manual instead of mechanical compaction. This is expensive and not an efficient operation. Generally, the minimum distance that should be used for mechanical rolling is 4 feet. This means that the 2-foot-wide longitudinal gutter, in a 20-foot-wide alley, should have a maximum offset distance from the gutter centerline to the alley centerline of 5 feet. The desirable transition length of longitudinal gutter to be used, where the gutter is offset from the alley centerline, is 15 feet.

**E 617.13 Gutter Arrangements at Alley Intersections:** Referring to Figure E 617.13, the flow of one alley (if directed toward another alley) is generally effected by means of connecting one gutter to the other. To facilitate flow at intersections of alleys with streets, and to reduce gutter overflow at the gutter connections of two alleys, the intersecting gutter should be angled-off in the direction of the flow of the intersected gutter (where the intersected gutter has a relatively steep grade). Usually, if an intersecting alley is draining away from an intersected alley, no gutter connection is needed.

**E 617.14 Concrete Fillets at Alley Gutter Intersections:** The use of concrete fillets as shown on Figure E 617.14, Plates I and II, is advocated for the following reasons:

1. They eliminate sharp-angled corners and the problem of mechanically rolling and compacting asphalt concrete in these corners.

2. They prevent the cracking and unraveling of the asphalt concrete pavement that tend to occur in these corners as a result of water overflow from the concrete gutters.

3. They reduce overall maintenance costs by lessening the shock to, and deterioration of, concrete gutter resulting from repeated vehicular impact.

**E 617.2 Structural:** The basic pavement thicknesses and the supporting materials for the paving of streets and alleys have been discussed in Section E 422, Pavement Design (Structural).

Alleys paved with asphalt concrete pavement and 10 percent in grade should either use the thick-lift construction process or have the pavement rolled in two separate courses of equal thickness.
Cul-de-sacs may be created as a means of access control, and are used in areas in which the nature of the terrain, interfering existing improvements, and economic considerations restrict, or fail to justify, the use of a through street. Elbow curves are flared curves that are used to improve an abrupt change in street alignment. This section discusses methods of meeting the requirements of cul-de-sacs and elbow curves.

However, a border could be 10 feet wide and have a 4-foot sidewalk and a 6-foot parkway. The reasoning behind this is that the minimum "Y" distance of a driveway apron is 6 feet to allow modern cars to negotiate the driveway. Only with prior special approval of the City Engineer should deviations from these criteria be made.

In all cases in which industrial zoning prevails, the curb radius for the cul-de-sac turning area is a minimum of 50 feet.

All dead-end streets are operated two-way and should be wide enough to permit turning around. If the street is wide enough, a dead-end can be made simply by providing a barricade across the street, possibly with a curb in front of it, supplemented by adequate warning signs and markers. Streets terminated by freeways or other arterial highway construction or by steep terrain are not likely to be sufficiently wide, in which case their ends should be altered to enable vehicles to turn around.

New subdivisions or private streets should always be required to provide a turning area. Figure E 113, Standard Street Dimensions, shows cul-de-sacs and alley turning areas. Where unusual conditions prevail, modifications of the turning area similar to those shown on this figure may be made. However, these altered shapes must provide equivalent minimum turning space.

Referring to Figure E 113 again, the turn-around curb radius for all cul-de-sacs is a minimum of 35 feet. Upon entering a cul-de-sac, a motorist encounters a length of curb radius which is tangent to the normal street curb and forms a reverse curve with the turn-around curve. The radii of these lengths of curve are a minimum of 50 feet. The border width should be maintained around the cul-de-sac configuration on new streets, and on existing streets where feasible. This border width is to be used only where abutting property is to be serviced. However, on existing streets, a minimum of a 6-foot-wide border may be provided. For example, if a sidewalk is included as a part of the border, it must be a minimum of 6 feet in width. Obviously, if a 6-foot-wide border includes a sidewalk, it would consist entirely of sidewalk.

Vertical curves should be used to provide a smooth transition between the steep street grade and the reduced cul-de-sac grade. The length of vertical curve should be based on a vehicle speed of 25 miles per hour. For cul-de-sacs located at the high end or low end of a steep street, the charts that should be used for determining the vertical curve length are on Figures E 342.1, Stopping Sight Distance on Crest Vertical (Summit) Curves, and E 342.2, Headlight Sight Distance on Sag Vertical Curves. It is presumed that vehicles will travel at a very low speed in turning around a cul-de-sac. Therefore, if necessary to meet existing improvements, a maximum curb break of 2 percent may be used at or near the high or low point (usually the point of grade reversal) of the curb grade around the cul-de-sac.
The crown used for the cul-de-sac area is determined by the formulas shown on Figure E 421.1C, Defining Crown Section. The result to the nearest \( \frac{1}{2} \)-inch is 0.50 feet for the standard turning radius of 35 feet.

The maximum desirable crossfall across the cul-de-sac at a section that is perpendicular to the centerline of the street and produced across the cul-de-sac radius point is 2½ percent from flow line to flow line.

**E 623 ELBOW CURVES**

It is desirable to design hillside and local streets to maintain a vehicular speed of 25 miles per hour. Therefore, where L-shaped intersections or sharp curves are encountered, the minimum horizontal radius that may be used is 300 feet for flat streets and 132 feet for hillside streets. In those cases where a 132-foot centerline radius is used and where the radius is immediately preceded by a tangent section of more than 350 feet or a downgrade in excess of 10 percent, an elbow curve (flared curve) should be provided. This elbow curve should be introduced at the vicinity of the acute alignment change.

The elbow curve may also be used to allow for increasing the frontage of adjacent lots where it is necessary to meet requirements of the Municipal Code. The widening of the curve is accomplished by increasing the outer property line radius by a maximum of 10 feet. The formula for determining this radius is:

\[
C.L. \text{ radius of the street} + \frac{W}{2} + 10' = r
\]

For example:

\[
132' + \frac{44'}{2} + 10' = 164'
\]

Therefore, the outer property line radius would be 164 feet. See Figure E 623, below.

Any deviations from the above requirements should be approved by the Division or District Engineer.
A driveway is generally a strip of land which is used to provide vehicular access from the public street to adjacent property. In conjunction with this use for a particular type of driveway, reference is made to Figures E 630A(1) and (2) and E 630B(1) and (2). These figures give the technical aspects of construction and some of the different types of driveway conditions. To facilitate the discussion of driveway design, the various component parts that comprise the driveway are illustrated on these figures as well as defined below.

1. The Driveway Approach is that portion of the driveway lying in the public right of way between the curb face or roadway of a public street and the property line thereof, and including both apron and side slopes. Except where there is a possibility of a misunderstanding, this Manual will merely use the term “driveway” in place of “driveway approach”. That portion of the driveway lying on the abutting property is also referred to as a driveway, but may have to be further qualified by the addition of the term “private” or “public”, according to its use.

2. The Apron is that portion of the driveway approach, exclusive of the side slopes or the driveway curb returns, extending from the gutter flow line to the property line. Since the apron is usually comprised of two distinct rates of slope, that portion confined to the Y distance will be referred to as the “Y Slope”. That portion between the top of the Y slope (normally the front of sidewalk) and the property line will be referred to as the “Sidewalk Area” of the apron.

3. The Side Slope is that portion of the driveway approach which provides a transition from the normal curb grade to the grade of the apron by means of a sloping surface. The horizontal distance of these side slopes, as measured at the curb line, is referred to as the “X Distance”. The side slope is the curb face (zero horizontal distance) where a curb return is used. See Case 3 or Case 4 on Figures E 630A(1) and (2) and E 630B(1) and (2).

In providing satisfactory vehicular access, the designer should follow the City’s driveway design policies and standards. These design criteria will be presented in the following discussions.

Driveways are constructed of either concrete or asphalt concrete pavement. Concrete is used for permanent construction in fully improved streets. Asphalt concrete pavement may be used in unimproved or partially improved streets under the following circumstances:

1. When used for:
   a. Temporary access or construction, such as bypasses or detours.
   b. Unimproved streets when there is little likelihood of their being improved in the near future.
   c. Temporary widening of improved streets until such time as they are widened to their ultimate width.

   (When driveways are paved or permits issued for driveway construction under these circumstances, the City may require a signed waiver from the involved property owner. Since the driveways are considered temporary and the permits are usually made revocable, the driveway may be eliminated, or the pavement may be removed and replaced with concrete pavement. This may be done at the request of the City, such as when other permanent street improvements are constructed that require the use of concrete pavement as previously indicated, or under permit, at the property owner’s request.)

2. Where the street has existing asphalt shoulders or berms, or where either is designated for construction in lieu of concrete curb.

3. Where asphalt driveways have been constructed between the curb or edge of pavement and the property line on the majority of properties in the block.

4. Where unusually wide parkways have existing sidewalk or indicate a proposed sidewalk at a relatively large distance from the property line. Asphalt driveways may be constructed between the back of the existing or proposed sidewalk and the property line.

5. Where abrupt slopes exist between the curb and the property line, and the likelihood of future sidewalk construction appears remote.
E 632 PROHIBITED LOCATIONS FOR
DRIVEWAY APPROACHES

Driveway approaches should not be constructed in the following locations or under the following conditions:

1. Under permit, when the Standard Plans cannot be followed because of local conditions. However, if the design office permits a deviation and obtains a signed waiver from the property owner, construction may be permitted.

2. When records do not show an official street grade. Construction may take place only after an official street grade has been established.

3. Where vehicular access to property is already provided from an abutting alley. However, if there are existing driveways serving more than half of the properties within a given block, driveways may be constructed at the discretion of the design office.

4. Between the prolonged intersecting property lines at any street or alley intersection, or between the points of curvature of any curb return having a radius of 20 feet or less. Under certain conditions, a driveway may be merged with an adjacent alley intersection.

5. Where only partial ingress of vehicles onto private property for the purpose of loading and unloading is possible (where vehicles parked across the sidewalk would prevent full and free use of the sidewalk by pedestrians).

DRIVEWAY APPROACH
SERVING C-2 OR LESS RESTRICTIVE ZONED PROPERTY

Figure E 632
State law requires that sidewalks and curbs be accessible and usable by the physically handicapped. Accordingly, access ramps are necessary at street intersections and other pedestrian street crossings to provide a continuous usable route to places of public accommodations.

City policy relating to access ramps was established by the Board of Public Works on January 10, 1975 as follows:

Access ramps shall be provided at all street intersections and corners where new curbs are installed or where curbs are substantially altered or repaired whether such work is being done with public or private funds.

Although the principal proponents of access ramps have been physically handicapped people confined to wheelchairs, people with other disabilities as well as the senior citizens have been considered in formulating the City's design criteria and standards. The design criteria and standards should be followed wherever possible. However, because of the many variables involved, each street intersection is a special problem and requires the use of sound engineering judgement.

E 632.1 DESIGN CRITERIA

The primary concern is the safety of persons using the access ramp. The ramps must be designed to accommodate everyone; wheelchair users, the blind using a cane, people with other physical disabilities, and the able bodied.

Ramp slopes must be moderate to be usable by wheelchair occupants without assistance. Ramps should not be provided along streets which have grades too steep for safe use by the handicapped.

While a ramp provides no particular benefit to the blind a uniform location and surface texture is important for orientation.

At least some curb face is needed at the foot of a ramp in order for the blind to locate the curb line. Conversely, the curb face must be minimal in order to present no serious obstruction to the passage of wheelchairs.

Sufficient ramps shall be provided at a given intersection or pedestrian crossing to avoid trapping a handicapped individual with no exit other than the entrance way.
632.2 DESIGN STANDARDS

Design elements to be considered include the following:
Location, slope of ramp and sides, width, curb face (lip),
construction material, surface texture.

632.21 LOCATION OF ACCESS RAMPS

Access ramps should be located so as to be safe for the
people using them. The ramp should be within the limits of
existing or proposed crosswalks. Coordination with the Traffic
Department may be required to assure compatibility between the
ramps and crosswalks.

632.211 ACCESS RAMPS AT THE MC

An access ramp at the MC, as illustrated on Figure
632.211A is preferred for the following reasons:

A. This location permits the construction of a single
ramp to serve two crosswalks.

B. The area is generally clear of utilities.

A safe refuge should be provided at the foot of the
ramp to avoid forcing wheelchairs into the path of moving
vehicles. A refuge is particularly important where the cross-
walks are marked and traffic is using the curb lane.

The area available for refuge is dependent on the curb
radius and the delta angle and whether the crosswalk lines are
offset from the curb lines produced. The amount of refuge is
characterized by a distance, M, measured along a radial from the
curb line to the intersection of the crosswalk lines. M should
be a minimum of 3 feet.

The Department of Traffic prefers that the crosswalk
lines be offset 3 feet back of the curb lines produced. With
the usual 3-foot crosswalk offset, a minimum curb radius of
17.5 feet would be needed when the delta is close to 90°. Where
the normal 25-foot curb radius is used an adequate refuge can be
provided where the delta is greater than 77°. Sufficient M could
be obtained by increasing the curb radius or securing Traffic
approval for a lesser crosswalk offset. The M available by
various combinations of crosswalk offset, curb radius and delta
is given in Figure E 632.211B.

Refuge areas are of little importance where there are
no painted crosswalks and traffic is light, such as generally
the situation in single family and rural areas.
E 632.212 ACCESS RAMPS AT OR NEAR THE BCR

Access ramps at or near the BCR should be used only if it is not possible to place a ramp at the MC. The three types (A, B & C) shown in the Figure E 532.212 illustrate the variations in location. These ramps can be used individually or in any combination. However a minimum of 6 feet of full height curb should be provided between ramps for safety and aesthetic reasons. Following are reasons why this location is not preferred:

A. A ramp at any of these locations can serve only one crosswalk.

B. These locations do not provide the uniformity desirable for the blind.

C. Type A location sometimes is partially occupied by utilities.

D. Type B location is generally occupied by traffic signals, street lights, fire hydrants, catch basins, power poles, etc.

E. Type B location would usually require relocation of the crosswalk.

Reasons why these locations might be appropriate include the following:

A. These locations are applicable when the return has insufficient delta angle to provide a refuge area required for an MC location.

B. Type C location is preferred when only one ramp is required because pedestrian crossings in the other direction are restricted or not desirable.

C. Type B locations can be used in pairs without regard to curb return radius or delta.

D. Type B locations leaves full height curb in the return for the benefit of the blind.

E.632.213 ACCESS RAMPS AT OTHER LOCATIONS

Ramps shall be provided at mid-block crosswalks and crosswalks at jogged intersections. Ramps shall also be provided at curbed driveway entrances to private property and at alley intersections where a curb face is maintained across the sidewalk area. See Figure E 632.213.
**E 632.22 SLOPES**

**Ramp Slope** - A ramp slope of 12:1 is desirable. If space limitations do not allow a 12:1 slope then an 8:1 slope is acceptable. In cases where space is limited and where pedestrian traffic is light a maximum slope of 6:1 may be used. The length of the ramp slope will be termed the "Y" distance.

**Side Slope** - The side slope is primarily determined by the curb height. A desirable side slope is about 12:1. However the "X" dimension should not exceed 6 feet; therefore if the curb height is more than 6 inches, the "X" slope will exceed 12:1. Furthermore, where there are space constraints the "X" distance may be reduced to 4 feet and sloped allowed to exceed 12:1. In areas where pedestrian traffic is very light a maximum "X" slope of 6:1 is permissible.

The length of the side slope, measured along the curb line, will be termed the "X" distance. Some special considerations of the "X" are as follows:

A. When the "X" slope is adjacent to a landscaped parkway or encompasses a single pole, utility pole, etc. as illustrated in Figure E 632.212, use an x = 4'.

B. Where the top of the "X" slope is within 1' of the B.C.R., use the B.C.R. as the top of "X" slope as illustrated in Figure E 632.211A.

C. The "X" portion of the ramp near the top serves as a transition from the ramp to the sidewalk. Therefore no landing at the top of the ramp is needed.

**E 632.23 WIDTH OF RAMP**

Use width of w = 4' dimensioned on the curb. Where the ramp narrows away from the curb, maintain a minimum of 3' at the top of the ramp.

**E 632.24 CURB FACE**

Use 1/2-inch curb face, with a specified tolerance of zero inch plus and 1/8-inch minus in the "W" portion of the ramp as shown in the sketch below.
Though no curb is desirable for the handicapped in wheelchairs, it is a distinct safety feature for the blind. With no curb in the ramp, a blind person could leave the sidewalk and enter the street without knowing it. Therefore, a small curb face is necessary to help the blind locate the curb line.

E 632.25 TEXTURE

The texture on the ramp surface shall be rougher than the texture used on the surrounding sidewalk. The rough texture will provide the necessary non-slip surface on the steepened grade. The change in texture will also help to warn a blind person of the ramp's presence.

A. In all cases a ramp shall have a wood float or rougher finish.

B. In sidewalks constructed with terrazzo, pavers (brick, tile, or granite block) or any other special surface, the ramps shall be constructed of a material with rougher texture.

E 632.26 MISCELLANEOUS DESIGN CONSIDERATIONS

The designer will encounter special situations which should be given special consideration such as the following:

A. Where drainage conditions will permit it may be desirable to raise the flow line in the curb return to provide a reduced curb face to accommodate ramps. The reduced curb height will help to shorten ramps placed in narrow sidewalks and/or reduce the slope of the ramps.

B. Where there is a narrow sidewalk and the flow line of the gutter cannot be raised to reduce the curb height, it may be possible to drop the elevation of the back of the sidewalk to accommodate a ramp.

C. At intersections where pedestrian crossings of one street are restricted, or not desirable, the ramps should be oriented to the direction of pedestrian flow as illustrated in Figure E 632.212 (Type C).

D. Ramps should not be provided along streets where grades are so steep that they cannot be safely used by the handicapped.
E 632.27 COORDINATION

Traffic Department

It is necessary that the access ramps be located within the limits of marked crosswalks. In some cases it may be desirable to adjust the location of crosswalk lines in order to make them compatible with the best location for the ramps.

The Geometric Design Section of the Traffic Department should be consulted for assurance that adjustment of the crosswalk location will be accomplished when necessary for compatibility with a proposed ramp.

The Geometric Design Section of the Traffic Department should also be consulted when particular problems are encountered at the following types of street intersections:

A. "T"
B. Jogged
C. Sharp angle
D. Multi-leg

Street Maintenance Bureau

The construction of curb ramps, if confined to the limits of a specific project, would in many cases result in a ramp at only one corner of an intersection. Under this condition a handicapped individual could be trapped in an intersection which had no exit other than the entrance way.

Types of projects on which this might occur include permit and assessment. Permit work in connection with private development generally does not extend beyond the street center lines or beyond the centers of intersections at the ends of the project. Assessment projects are also normally terminated at the centerlines of street intersections for convenience in setting assessment district boundaries.

In order to assure that adequate access ramps will be provided at intersections where construction work is to be undertaken the design offices should take the following actions:

A. On publicly financed projects (CIP, Combination), complete ramping shall be provided at all intersections involved.

B. On other projects (B-Permit, Assessment), if a ramp is installed at one corner, ramps at the other
corner's shall be installed by the Bureau of Street Maintenance upon request. The Street Maintenance work should be coordinated with the Permit or Assessment project construction.

2. Memorandum requests to the Bureau of Street Maintenance for ramp construction shall be considered routine correspondence in accordance with Subsections B123 and B131 of the Office Guide. Copies of such memoranda shall be directed to the Engineer of Design who shall maintain a City-wide record of such requests.

D. Plans prepared for Street Maintenance projects shall include ramps required in the intersection involved.
6. Where no ingress of vehicles onto private property is possible.

7. Where the curb or berm to be depressed will not include improvement of the area bounded by the curb or berm depression and the property line.

8. Where a driveway approach which serves “C-2” or less restrictive zoned* property is constructed less than 5 feet from an adjoining “A” or “R” zoned property. To determine whether a minimum of 5 feet is provided, find the distance to be measured by drawing a line, perpendicular or radial to the curb, from the intersection of the side lot line and the street property line, regardless of the angular relationship between these lines. See Figure E 632, below.

E 633 WIDTHS AND SPACING OF DRIVEWAYS

The minimum width (W) of a driveway apron should be 9 feet (exclusive of side slopes) in “A” and “R” zones and 12 feet on “C”, “M”, “P”, and “PB” zones. The maximum should be 18 feet in “A” and “R” zones and 30 feet in “C”, “M”, “P”, and “PB” zones. Exceptions to such limits may be granted by the Bureau of Engineering. Not less than 20 feet of full-height curb should be retained between driveways located to serve the same lot. Not less than 20 feet of continuous curb space should be retained in front of each lot for which the street frontage of the property served is greater than 40 feet. Where such frontage is 40 feet or less, continuous curb space equal to one-half the length of the frontage should be retained in front of each lot. However, this provision should not be applied to prevent the construction of one driveway per lot having a width of 9 feet in “A” and “R” zones and 12 feet in “C”, “M”, “P”, and “PB” zones. Where driveways serving separate lots are so located that at least 2 feet of full-height curb separating the driveways cannot be constructed, the two driveways should be merged into one. If a permit is involved, any exceptions should be noted on the permit.

Consideration will be given to the potential use of the property. Generally speaking, commercial driveway construction is required to serve all commercially zoned property. Where property is to be used for commercial or industrial use, care should be taken to limit the total length of driveways to a reasonable distance. For all property frontages of over 50 feet, the total length of driveways should not exceed 60 percent of the frontage. For frontages of less than 50 feet, one 30-foot-wide driveway may be permitted.

E 634 EFFECT OF SIDE LOT LINES ON DRIVEWAYS

Except for side slopes, no portion of a driveway approach should extend in front of an adjoining lot without the consent of the owner of the lot. For exceptions, see Section E 632(8). For this purpose, the division between two lots should be a line which is perpendicular or radial to the curb and passes through the intersection of the common lot line and the street property line, regardless of the angular relationship between these lines.

All driveways should be constructed at right angles to the curb. When the curb line is curved, the driveway should be constructed on a line radial to the curb.

E 635 DRIVEWAY DESIGN

The street designer is usually required to design only that portion of the driveway lying between the curb and the property line. However, occasionally driveways located on private property may also have to be designed. This may require meeting certain Department of Building and Safety driveway requirements and other design considerations. See Section E 635.3. In addition, the problem encountered may differ for driveway design on fully improved streets as opposed to partially improved or unimproved streets. Standard driveway design as well as design under these other conditions will be covered below.

E 635.1 On Improved Streets: An improved street usually has an officially established street grade. Using this established grade, the longitudinal and transverse driveway grades are determined. The transverse driveway grade is usually laid parallel to, and in the same vertical plane as, the longitudinal street curb grade. The curb is then depressed and a longitudinal driveway grade is designed to connect the top of the depressed curb to the property line. The various driveway components that may require design include the depressed curb, the side slopes or curb returns, the Y slope, and the sidewalk area of the apron.

*Requirements apply to any automotive service station, tire and tube repairing, battery service, automobile lubrication, automobile laundary, or wash rack establishment.
E 635.11 Depressed Curbs: The treatment of existing and proposed depressed curbs depends on the property owner's intent and continued use of the driveway. The extent to which the existing or proposed street has been or will be improved may also affect the depressed curb design details.

E 635.111 Existing: Driveways or depressed curbs which have been abandoned should be removed. The depressed curb should then be replaced with full-height curb (prevailing curb height). The border portion should be completed to conform to the City's border requirements. See Section E 450, Borders. The sidewalk area of the apron may be left in place if it is in satisfactory condition.

If a portion of the driveway has been previously constructed and meets the City's standards as to grade, condition, and thickness (a minimum of 3 inches thick for existing residential driveways), a change of curb grade requires a new Y slope to be constructed. Under these conditions, the remaining portions of the driveway may remain in place and be joined by the new driveway Y slope. If an existing driveway is to remain in use and the depressed curb does not conform to the latest Standard Plans, the nonconforming depressed curb should be removed before a new Y slope is constructed. The new depressed curb and Y slope should then be constructed monolithically, as indicated in Subsection E 635.112, below.

E 635.112 Proposed: The proposed depressed portion of the curb (lip) is constructed 1 inch above the existing flow line of the concrete pavement or gutter. Where the prevailing curb face in the vicinity of the driveway is 6 inches or less, and if the pavement adjacent to the curb is bituminous material, the depression may be constructed flush with the pavement (0-inch lip). If the prevailing curb face is higher than 6 inches, a 0-inch curb face may result in too steep a slope for the driveway apron.

It may be necessary to provide better vertical clearance due to the scraping of the vehicle's underparts on high roadway crowns, steep driveways, abrupt grade breaks, etc. If the adjustment of these factors appears unfeasible, a maximum of a 2-inch-high lip may be used if it will help correct the vertical clearance impairment.

E 635.12 "Y" Slope of Driveway Apron: The design standards used for the Y slope construction are based on Figures E 630A(1) and E 630A(2). As the table on Figure E 630A(1) indicates, the horizontal length of the apron to be used is dependent on the existing or proposed curb face. Where the length of apron used will result in the top of the Y slope extending into the sidewalk area, a Case 2 or Case 4 driveway should be used.

These figures are based on standard streets with standard borders (distance between curb and property line). However, on some streets, particularly hillsides, there may be only a substandard width border available or some other peculiar existing condition. This may require the use of some combination of curb face and Y slope, as indicated on the table of Figure E 635.12. In any case, the combination used should not result in a percentage slope of the apron below the heavy line shown on the chart. If these values are exceeded, the vehicle's vertical clearance must be checked by use of the templates, as discussed in Section E 635.4.

E 635.13 Sidewalk Area of Apron: The driveway grade should be set extending upward from the top of the Y slope at the rate of 2 1/2 percent. See the sketch on Figure E 635.12. However, in certain situations some latitude in driveway slope is required in order to meet existing improvements or to improve the impaired vertical clearance of a vehicle traversing the driveway. The driveway slope may be varied upward from the top of the Y slope to the property line, from a minimum of 1 percent to a maximum of 6 percent.

E 635.2 On Unimproved or Partially Improved Streets: Driveways may be constructed on streets that are unimproved or partially improved, but may be subject to certain conditions as described below.

E 635.21 Where a Street Grade Has Been Previously Established: The unimproved or partially improved streets may have existing abutting property which is undeveloped or partially or fully developed. It may be found that where the street grades have been established in prior years, little or no regard was given to these grades when some or most of the abutting property was developed. Or another situation may be found where the existing improvements have been constructed to
the established grade but a construction problem exists at a particular proposed driveway location.

E 635.211 Driveway Construction to Meet Established Street Grade: Where little or no improvement has been made to abutting property, a property owner must construct the driveway to the established street grade. In hillside streets at the site of the proposed driveway, the existing terrain may be considerably above or below the established grade.

A transitional grading section must be provided between the proposed grade of the driveway and the existing street grade on either or both sides of the driveway. This transition section must provide a smooth grade, adequate sight distance, and good drainage. Under these circumstances the driveway construction may create grading and drainage problems, as discussed below.

1. Grading — The transition grading may require the raising or lowering of existing garage floors, the remodeling or redesigning of existing buildings or buildings being designed, or the construction or reconstruction of sidewalks, walls, driveways, etc., on private property.

Due to the varied nature of the problems encountered in this regard, reference is made to other Parts of the Manual and other Chapters, Sections, or Subsections of this Part of the Manual. It is further urged that the street designer consult with other offices; for example:

a. Storm Drain Design Division or the Storm Drain Section of the District — On drainage.


c. Bridge and Structural Design Division or the Department of Building and Safety — On structures.

d. Street Opening and Widening Division or the Bureau of Right of Way and Land — On right of way.

e. City Attorney — On legal matters.

f. Other involved offices — On their specialties.

2. Drainage — Drainage problems may develop as a result of extensive grading, by erosion, or by the creation of a sump.

a. Erosion control — The street runoff from a small residential lot may be considered a negligible drainage factor. However, the roof, parking area, and other impervious surfaces of the lot may drain toward the street. When the driveway is constructed to concentrate and channelize the flow of water to the unimproved street, some form of drainage control must be included with the driveway construction. Driveways should not normally be designed nor permits automatically issued for this drainage situation. However, it may be determined by field inspection or design study that the driveway pavement will eliminate poor drainage conditions, such as local water pockets in a graded gutter, and will not worsen the drainage situation. If this is the case, the driveway construction should be permitted.

b. Sump elimination — The elimination of accumulated water where a sump may be created occurs when the driveway construction and the accompanying grading result in the formation of a sump in the street or the blocking of drainage from abutting property.

When the street is unimproved and the development is limited to only one or two properties, the costs incurred by one owner due to drainage and construction problems may be prohibitive. This may prevent property development until such time as the entire street is improved and the costs shared by all or most of the property owners.

E 635.212 Driveway Construction Not to Meet Established Street Grade: Where most of the property has been developed, it may be extremely costly to require all of the property owners to build or rebuild the driveways and possibly garages, walls, sidewalks, etc., to the established street grade. In this case it may be found expedient to reestablish the street grade to meet the existing improvements. The proposed roadway and the proposed driveways would then be constructed to the new grade. However, before attempting to redesign the established street grade, the Division or District Engineer or his assistant should be consulted.

E 635.22 Where No Street Grade Has Been Previously Established: A grade should be determined for the entire street where no street grades have been previously established. The design criteria as outlined by this Part of the Manual should
be used. The driveway grade is then superimposed on the proposed street grade profile. Adjustments should be made to the proposed street grade at the proposed driveway site to minimize the cost of the driveway construction. However, this adjustment should be made without sacrificing the City's design standards or policies, and should not be made at the expense of the existing or future development of abutting properties.

E 635.23 Streets With Curb Only (Roadway Not Paved): At locations where curb has been or will be constructed and where there is no existing or proposed roadway pavement, the elevation of the top of the depressed curb should be 7 inches below the top of a theoretical 8-inch curb face, 6 inches below the top of a 7-inch curb face, 5 inches below a 6-inch curb face, etc. These streets are subject to erosion problems, as discussed in Subsection E 635.211.

E 635.24 Streets With No Curb and With or Without Pavement: Generally, streets that are unimproved or partially improved have little or no drainage control, as discussed in Subsection E 635.211. Where there is no existing or proposed curb on the street, construction of the driveway curb, which may extend into the traveled roadway, may constitute a traffic hazard. Therefore, adequate safety measures must be added to warn or divert traffic. These measures may include installation of such appurtenances as guard rail, warning rail, or guide posts; also grading, the construction of temporary berms, etc. At such time as the street is further improved, these protective devices may be modified or removed.

If installing these protective devices is not deemed desirable, it may be advisable to use a temporary asphalt driveway. See Section E 631. The asphalt driveway is then constructed to the established grade. The pavement is constructed flush with the surface, and curbs are omitted.

E 635.3 On Private Property: The proposed street and driveway grades should be adjusted to avoid any abrupt grade or alignment difference between such driveway within the public street and the existing driveway on private property. Where this abrupt difference cannot be eliminated, a sufficient portion of the driveway located on the abutting property should be removed. A smooth transition can then be constructed to offset these differences.

The Department of Building and Safety standards for driveways on private property should be met, where possible. These standards are:

1. The grade used for access to any garage or required parking area should not exceed 20 percent.
2. The cross slope of the driveway should not exceed 10 percent.
3. The maximum slope of a required parking space in any direction should not exceed 5 percent.
4. The minimum dimensions for the above parking space should be 8 by 18 feet.
5. The minimum vertical clearance for the vehicular entrance to the garage is 6 feet, 6 inches. This should be considered in changing the driveway grade or approach slab elevation.

Where right of entry or easements are required for work done on driveways, the right of way sketch should show the maximum grade to which the driveways are to be reconstructed. See Figure E 823B, Typical Final Sketch.

E 635.4 Design Check of Vehicular Vertical Clearance: The Bureau may permit the driveway grade on private property to exceed 20 percent. However, the most critical section of any driveway design should always be checked for vehicular vertical clearance and negotiability.

A suggested method is by use of the clear plastic automobile templates which are included in the pocket of the cover of this Part of the Manual. These templates are designed as the composite shortest and longest vehicles referred to in Section E 222, Vehicular Clearances. They have been scaled to 1 inch equals 2 feet horizontally and vertically.

For testing the traversability of the driveway, the profile of the most critical vehicular paths should be plotted on 10 x 10 cross-section paper. The most critical path is usually where the vehicle is backing out of the driveway toward the uphill direction of the street. The profile should be plotted on the same scale as the templates; that is, 1 inch equals 2 feet horizontally and vertically. This profile should include a length of the existing
or proposed street grade. The plotting should extend from the driveway onto the street to at least the street centerline or along the probable path of a vehicle both entering and leaving the driveway. It should also include a length of plotted profile of the existing driveway extending from the property line onto the abutting property a sufficient length to permit the vehicle's access to such property. The proposed driveway grade is then superimposed between these limits.

The templates should be moved along the plotted profile, noting whether any under portion of the vehicle touches the profile line. Any contact of the vehicle with the profile line should be avoided by design adjustments. In using this testing and design procedure, it may be found that satisfactory vehicle access cannot be economically provided. This information should be transmitted to the Bureau of Right of Way and Land according to the procedure outlined in Section E 800, Procedural Steps for Proposed Improvements.
Intersections fall into two broad classifications: intersections at grade and grade separations. The following discussion covers the location and design criteria of grade separations. A discussion of intersections at grade is presented in Section E 650.

E 641 WARRANTS FOR GRADE SEPARATION

In justifying the use of a grade separation, consideration is given to the type and volume of traffic, topography, available right of way, number of accidents, and economic costs. Due to the high cost, the City has limited its use of grade separations to the intersections of railroads with major and secondary highways. As basic guides for determining the need for railway grade separations, one or both of the following criteria may be used:

1. When the average daily traffic times the number of trains equals 80,000 with at least 8 trains per day.

2. When there has been one accident per year during each of the last five years in which a train and a motor vehicle have been involved.

The final judgment as to the need of a railway grade separation should take into account the characteristics of the terrain, the existing surrounding improvements, and economic feasibility. Since the funds available are limited and there is a need and justification for these structures throughout the City, a priority list for the construction of these projects has been established. This list is subject to change, as are the existing traffic conditions and fund availability.

E 642 PRELIMINARY DESIGN CONSIDERATIONS

The design of the structure proper, the setting up of the critical path, and the carrying through of the design project are functions of the Bridge and Structural Design Division. This Section of this Part of the Manual, however, will deal with that portion of design criteria that the street designer considers jointly or independently with other agencies.

It has been established that most often it is not economically feasible to realign or alter the grade of the rails. Therefore, consideration is mainly devoted to realignment and grade change of the highway. However, this does not mean that the possibility of a change in the railway should be overlooked.

To make this highway alignment and grade determination, it is customary for all agencies involved to make a joint field trip to the proposed site. Contour maps and aerial photographs are an invaluable aid in making an overall preliminary study. Some of the items to be noted at the proposed site are the terrain, the extent of existing improvements, and the availability of right of way. These factors will influence the decision as to the final highway alignment, whether it is more economical in terms of construction and right of way costs to build the highway over or under the rails, and possible locations for the railway shoofly and temporary highway detour. (A railway shoofly is a temporary track laid on the ground or on cribwork at one side of the railroad line to permit trains to pass during the completion of a construction project.)

E 643 OVERPASS VERSUS UNDERPASS

Since cost is an important consideration, several preliminary layout plans including overpasses and underpasses should be made, comparing the advantages and disadvantages of each. The following factors should be examined and should influence the choice of using an underpass or an overpass:

1. Both the underpass and the overpass should fit into the existing topography, not only at the intersection but for the entire area to be utilized. This makes for a more pleasing appearance and reduces maintenance of extensive side slopes and pavements.

2. Both the underpass and the overpass require the use of open cut or embankments, which are usually less costly than concrete walls or retaining wall construction. However, side slopes may add to the cost of right of way and may require perpetual maintenance.

3. An underpass generally creates greater drainage problems, since a sump is created. The drainage facilities in sumps should be designed to remove surface runoff from a storm of 50-year frequency. This will usually require a major storm.
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E 644 DESIGN CRITERIA

In order to preserve continuity of the street, the design criteria for all elements of the grade separation are the same as those used for major or secondary highways. Some of these basic requirements, covered elsewhere in this Part of the Manual, are also listed here as follows:

1. The same cross-section and width of the particular highways concerned is carried on the approaches as well as on the underpass or overpass.

2. A design speed of 50 miles per hour should be used.

3. The geometric standards for horizontal and vertical alignment and for sight and stopping distances are the same as for major and secondary highways. Reference is made to the following:
   a. Section E 310, Horizontal Alignment.
   b. Section E 320, Vertical Alignment.
   c. Section E 330, Combination of Horizontal and Vertical Alignment.
   d. Section E 340, Sight Distance.
   e. Section E 410, Streets.
   f. Section E 450, Borders.
   g. Section E 640, Grade Separations.

4. Some railway bridges may be built with a clear span across the highway underpass. The medians should generally be a minimum width of 10 feet and preferably 14 feet. An absolute minimum width of 8 feet may be used where a pier is required. Where a left turn lane is necessary, an absolute minimum width of 10 feet should be provided. The length of the storage should conform to standards previously covered. Where the median strip is at least 10 feet in width, landscaping may be considered. Reference is made to Section E 460, Medians.

5. Minimum vertical clearance is 15 feet between the soffit of the bridge and the pavement of the highway underpass, and 22.5 feet between the top of the rails and the soffit of the highway overpass at that point over the rails. Reference is made to Section E 220, Design Vehicle Physical Characteristics and Minimum Clearances.

6. Maximum desirable grade on the highway portion of the grade separation is 6 percent; absolute maximum is 7 percent. Only with prior special approval of the City Engineer should deviations from these standards be made. Reference is made to Section E 531, Design Details.

7. Maximum grade break on centerline profile is 0.50 percent. Only with prior special approval of the City Engineer should any deviation from this standard be made. Reference is made to Section E 531, Design Details.
8. Maximum grade break at top of curb is 1.00 percent. Only with prior special approval of the City Engineer should any deviation from this standard be made.

9. Minimum grade of flow line at the curb is 0.250 percent. Only with prior special approval of the City Engineer should any deviation from this standard be made. Reference is made to Section E 420, Pavements.

10. Parabolic crown section is to be used. Only with prior special approval of the City Engineer should any deviation from this standard be made. Reference is made to Subsection E 421.1, Parabolic Crown Sections.

11. Side Slopes should have a maximum slope of 2:1. Only with prior special approval of the City Engineer should any deviation from this standard be made. Reference is made to Section E 480, Side Slopes.

E 645 TEMPORARY DETOURS

One of the most important considerations in highway design is the temporary highway detour and/or shoofly. See Section E 642. Detour considerations may affect the final alignment and grade of the intersection. It may also influence the underpass-versus-overpass decision, the use of walls or side slopes, the amount of right of way necessary, and the design and construction costs. As may be seen, temporary bypasses may represent a large percentage of the total project cost, and its design aspects should be thoroughly examined.

E 645.1 Design Criteria (Temporary Detours): The temporary highway detour should follow the identical design standards that are required of the major highway. Deviations should be considered only in the case of extenuating or critical circumstances or situations involving excessive costs. Two of these deviations are as follows:

1. Temporary pavement should be a minimum of 4 inches of asphalt concrete. An additional 4-inch minimum of select material base may be necessary.

2. Temporary sidewalks may be a minimum of 3-inch-thick asphalt concrete.
E 650 INTERSECTIONS AT GRADE

Most of the basic concepts presented in this Part of the Manual on highway and intersection traffic capacities, types of intersections, and their modification by realignment and channelization have been taken from other publications. Although these concepts have not been changed, recent editions of these sources of information have revised some of the terms and definitions, slightly altered or added new highway and intersection capacity charts and tables, and refined the previous procedures by incorporating a new degree of flexibility for local applications. Therefore, for a more recent, comprehensive, and detailed analysis, reference is made to the following publications:


E 651 GENERAL DESIGN FACTORS

With varying degrees of influence, four principal factors determine the characteristics of an intersection. These are:

1. Human factors.
2. Traffic factors.
3. Physical factors.
4. Economic factors.

Some of the elements that make up these factors have effects on the design of the intersection that are self-evident and require little or no explanation. Others require a more detailed study than is warranted in this Part of the Manual. Reference should be made to the traffic engineering texts for more detailed information. Since the street designer may be directly involved with the accumulation or use of some of these data, a short commentary is added at the end of the list of elements comprising each factor.

E 651.1 Human Factors: While drivers do not all act the same under all conditions, all drivers, to a greater or lesser extent:

1. Act according to habit.
2. Conform by following "natural" paths of movement.
3. Are susceptible to confusion from surprise.
4. Require adequate perception and reaction time.
5. Possess the ability to make correct decisions when faced with alternatives.

E 651.11 Compensating for Human Weaknesses: Corrective measures which tend to compensate for human weaknesses are:

1. Adequate sight distances.
2. Grade separations.
3. Smooth vehicular paths of travel.
5. Paths with a minimum area of vehicular conflict.

E 651.2 Traffic Factors: The factors to be considered include:

1. Channelization — capacity of channels relative to traffic flow.
2. Turning movements to be permitted and accommodated.
3. Size and operating characteristics of vehicles.
4. Vehicular speeds.
5. Controlling traffic flow at points of intersection convergence and intersection divergence.
6. Transit operations.
7. Pedestrian movements.
8. Accident experience.

The Department of Traffic usually supplies most of the above information in the form of flow diagrams and accident data. These data are used in determining the relative importance of conflicting traffic movements; the geometric requirements of the intersection, such as left-turn pockets, medians,
islands, and traffic controls; and cost-benefit ratios for establishing priority of construction, grade separations, etc.

E 651.21 Flow Diagrams: The average daily traffic (ADT) and design hourly volume (DHV) are indicated by the traffic flow diagram. It also indicates the time of day (a.m. or p.m.) of vehicles passing through or making turning movements within an intersection. The flow diagram states the year for which the indicated volume is anticipated and the expansion factor used, or to be used, in arriving at the volume for the design year. Some of the other factors have been previously discussed or defined. See Sections E 210, Traffic Data, and E 211, Volume.

Major movements as determined from the flow diagram should be given preference. To accomplish this, the type of traffic control devices to be used would have to be known prior to intersection design. Giving major movements preference may mean elimination of minor movements and may also affect channelization. Minor traffic movements may become a factor where there is a turning volume of 200 or more vehicles per hour (VPH) and where opposing through traffic exceeds 800 VPH during this same hour. A special design capacity study must then be made which would include traffic signalization and phasing control. When pedestrian traffic volumes are sufficient to affect the design, complete information on these present and future movements is necessary. All of the vehicular and pedestrian flow patterns must be considered when attempting to establish traffic control.

E 651.22 Accident Records: According to AASHO, “about 27 percent of all fatal accidents in urban areas involve collisions with other motor vehicles and more than one-half of these are angle accidents, indicating that the principal locations of accidents due to congestion in cities are at intersections at grade”. See Section E 020F(1d).

Many of these intersection accidents are a result of attempted left-turn movements. It is evident that all the types and causes of intersection accidents should be recorded and a determination of appropriate corrective measures included in the design study.

E 651.3 Physical Factors: In general, physical factors which control intersection design are topography, existing improvements, and physical requirements of the highway. These factors involve the following:

1. Total intersectional area.
2. Areas of possible conflict.
3. Intersectional angles.
4. Sight distances.
5. Speed-change areas.
6. Roadway grades, surface types, and cross-sections.
7. Character and use of abutting property.
8. Need for traffic control devices.
9. Number, size, and shapes of islands.
10. Need for and availability of lighting.

Information regarding the topography and existing improvements is needed to help determine the amount of right of way, the grade separation feasibility, the extent of profiles and cross-sections required, and the optimum angle alignment of the intersections.

E 651.31 Intersection Topography: Information regarding topography is generally available in the form of land (ground) surveys, AL maps (field work shown on topographical maps), and aerial photographs. This information is provided by the Survey Division of the Bureau of Engineering at the designer’s request.

The proposed type of intersection determines the form and extent of the survey information required. Very generally, where no additional right of way is needed, the normal intersection requires only a ground survey of the existing or proposed intersection and a profile and cross-section of the intersecting streets. For intersections requiring additional right of way, AL maps may be more advantageous. In making alignment and channelization studies, consideration should be given to the use of aerial photographs if it is anticipated that a ground survey will cost over $500.00.

It is suggested that where doubt exists, the designer should have a preliminary discussion with a survey supervisor of the Survey Division to determine the best method of survey for a particular project.
E 651.4 Economic Factors: Intersection design is often controlled by important economic factors. These are:

1. The cost of the improvement.
2. The economic effect on abutting businesses where channelization restricts or prohibits certain vehicular movements within the intersection area.
3. Benefits to the street or highway users.
4. Money available. Cost estimates of right of way parcels which may be affected by alternate designs are essential. Right of way cost data are normally obtained from the Bureau of Right of Way and Land.

E 652 INTERSECTION TRAFFIC CAPACITY

Section E 240, Highway Capacity, discusses the use of uninterrupted traffic flow for determination of highway capacity and the modification of this flow when interrupted flow prevails. One of the most important elements creating interrupted flow of traffic on a highway, particularly in urban areas, is the at-grade intersection. These intersections have considerable control of the vehicular and pedestrian traffic flow capacity of all City streets. Therefore, the terms “intersection operation” and “interrupted flow” are often used synonymously.

E 653 FACTORS AFFECTING INTERSECTION CAPACITY

The following factors indicate the data needed to analyze the capacity of a given intersection or to determine its required geometry for a given traffic volume:

1. Basic Physical and Operating Conditions:
   a. One-way or two-way operation.
   b. Parking conditions.
   c. Width of approach.
2. Environmental Conditions:
   a. Metropolitan area population.
   b. Location within the metropolitan area.
   c. Peak-hour factor.
   d. Load factor.
3. Traffic Characteristics:
   a. Traffic volume to be served on each approach.
   b. Turning movements.
   c. Trucks and through busses.
   d. Local busses (bus stops).
4. Control Measures:
   a. Traffic signals — functional type and phasing.
   b. Degree of channelization and approach lane markings.

Because so many factors influence interrupted flow through intersections, these flow criteria are developed around typical or average conditions. Adjustments either upward or downward, as indicated in Section E 654, may be applied to fit the specific conditions at hand.

E 654 SIGNALIZED INTERSECTION CAPACITY DATA

All of the factors as stated in Section E 653 are also used in determining signalized intersection capacity. Much of this data is supplied by the Department of Traffic. Various charts and tables supplied by previously mentioned public agencies are also included in this section to enable estimates to be made, under varying conditions, of the signalized intersection capacity.

E 654.1 Levels of Service: Figure E 654.1A, below, shows levels of service as related to load factor for individual, isolated intersection approaches. The load factors ranging from 0.0 to 1.0 as shown on the curves of the basic data in Figures E 654.1B(1) and (2), Plates I and II, and E 654.1C (1) and (2), Plates I and II, are indicative of levels of service. The load factor is a ratio of the number of green signal intervals that are fully utilized by traffic during the peak hour to the total number of green intervals for that approach during the same period. For intersection conditions, the Highway Capacity Manual considers the load factor as an appropriate measure of the levels of service, since the loading is something the driver sees and interprets in terms of degree of congestion. See Section E 020F(4a).
A level of service B-load factor of not more than 0.1 is considered in the Highway Capacity Manual to be suitable for design of intersections under typical rural conditions. A level of service C-load factor of not more than 0.3 is normally recommended for design of intersections in urban areas. A level of service E with operation at a load factor of 0.65 is taken to be representative of possible capacity. Although a factor of 1.0 may sometimes be approached, a lesser factor such as 0.65 generally indicates the maximum loadings that can be achieved repetitively and sustained over a period of one hour.

### Levels of Service

<table>
<thead>
<tr>
<th>Level of Service</th>
<th>Traffic Flow Description</th>
<th>Load Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Free flow</td>
<td>0.0</td>
</tr>
<tr>
<td>B</td>
<td>Stable flow</td>
<td>≤ 0.1</td>
</tr>
<tr>
<td>C</td>
<td>Stable flow</td>
<td>≤ 0.3</td>
</tr>
<tr>
<td>D</td>
<td>Approaching unstable flow</td>
<td>≤ 0.7</td>
</tr>
<tr>
<td>E</td>
<td>Unstable flow — capacity</td>
<td>≤ 1.0</td>
</tr>
<tr>
<td>F</td>
<td>Forced flow</td>
<td></td>
</tr>
</tbody>
</table>

**Figure E 654.1A**

**E 654.2 Factor f for Conversion of Design Capacity to Possible Capacity:** Using the load factors as stated in Subsection E 654.1 for rural intersections and for different street types, the relationship between design capacity and possible capacity is summarized in Figure E 654.2, below. The values shown are the ratios of attainable volumes per hour of green (average conditions) at 0.3-load factor (0.1 for rural conditions) to the attainable volumes at 0.85-load factor. Therefore, design capacity can be converted directly to possible capacity by multiplying design capacity by the appropriate factor f in the figure below.

**E 654.3 Factor f for Adjustment to Various Levels of Service:** Although Figures E 654.1A, E 654.1B, E 654.1C, and E 654.2 are based on design capacity (service level C for urban conditions and service level B for rural conditions), conversion to any other level of service can be achieved by the use of the factors shown in Figure E 654.3, Plates I and II. Thus, the figures may be used with equal facility to find design capacity and possible capacity in accordance with AASHO’s practice, or to find the maximum service volumes for any level of service (A to E), in accordance with the Highway Capacity Manual procedure.

**E 655 USE OF NOMOGRAPHS FOR DETERMINATION OF SIGNALIZED INTERSECTION CAPACITY**

The nomographs, Figures E 655A, Chart 1, and E 655B, Chart 2, represent two samples of twenty charts that are included in the Public Roads publications of August and October, 1967. See Section E 020F(3b2). These charts are used for making various adjustments to find design capacities for given roadway and traffic conditions. They are simple arrangements for determining the design capacity of one approach to a signalized intersection for average conditions. Average conditions constitute 5 percent trucks and busses, 10 percent right turns, 10 percent left turns, and no bus stops. Figure E 655A is for 2-way facilities, and Figure E 655B is for a 1-way facility. The upper part of each nomograph is a plot of the curves from Figures E 654.1B and C with a load factor of 0.3 for...
the different types of facilities (except for rural highways), parking conditions, and location within the metropolitan area. The curves show the relationship between the approach width and the design capacity for average conditions in terms of vehicles per hour of green. The lower part of the chart is a proportional graph that converts, for a given signal timing, the design capacity to a volume of vehicles per hour. The third graph unit on the right adjusts this volume to a given metropolitan size.

The two charts are applicable to situations where only approximate solutions are required or where specific traffic characteristics are not known. They also form the basis for developing additional nomographs for specific conditions. In the upper parts of the graphs are curves, five in Figure E 655A and eight in Figure E 655B, which are the basis for 13 additional detailed charts which are included in the publications. Each curve in the succeeding charts, expanded to a family of curves representing various percentages of trucks in the traffic stream, forms the upper section of a separate nomograph. The signal-timing adjustment (G/C ratio) part of the graphs in Figures E 655A and B is used to form the last section of the succeeding charts. The intermediate parts of the succeeding charts account successively for the effects of right turns, left turns, and metropolitan area size.

The first 15 charts are supplemented by an additional five charts. The first three of these five additional charts provide adjustments for conditions where there are bus stops at the intersection, determine capacities of separate right- and left-turn lanes without signal indication, and determine capacities of separate right- and left-turn lanes with separate signal indication.

The last two of these charts are designed for use in planning street systems and in preliminary design, or for review of plans where approximate but quick solutions are desired in terms of total or overall intersection capacity. Also, they are augmented by several tables and special conditions that can be used for complete analyses of practically any form of signalized intersection problem.

E 656 TYPES OF INTERSECTIONS

The basic types of intersections at grade are "T", "Y", 4-leg, multileg, and rotary. The rotary intersection is not commonly used in the City and the design principles involved will not be discussed in this Part of the Manual.

Any one basic intersection type can vary greatly in scope, shape, and degree of channelization. Once the type is established, it is a matter of applying the design techniques and criteria to arrive at a suitable geometric design for intersections. The types and some of the variations of each type are discussed in this section and are shown on Figure E 656.

E 657 GEOMETRIC MODIFICATION

The geometric modification of an at-grade intersection can be achieved, where necessary, by realignment and/or channelization.

E 657.1 Realignment: A right-angle intersection provides the most favorable conditions for vehicle operators to judge the relative position and speed of vehicles on the intersecting roadway. In addition, it provides the shortest crossing distance for intersecting traffic streams. Intersecting angles on a skew of not more than 30 degrees do not materially decrease visibility or increase crossing distances. Where the skew angle exceeds 30 degrees, consideration should be given to realignment of the cross-road as shown on Figures E 657.1A and E 657.1B. Additional measures that could be taken to reduce accidents and facilitate traffic movements are shown on Figure E 657.1B and are discussed below:

1. Intersection A is an example of an intersection that has a narrow street for one of the legs. The correction indicated is a gradual converging transitional alignment.

2. Intersection B is an example of an offset intersection where through traffic must generally slow down considerably or come to a complete stop. The corrective measure indicated is a long-radius reverse curve with intervening tangent sections. The skew angle that is provided should not exceed 30 degrees unless approved by the Division or District Engineer.

3. Intersection C is also an example of an offset intersection. The reverse curve alignment as shown creates an intersection angle of more than 30 degrees. If the topography, existing improvements, and economics permit, a large enough radius re-
verse curve system should be used to provide a skew angle of less than 30 degrees. The corrective measures taken would then be similar to that in paragraph 2, above.

4. Intersection D is an example of a multileg intersection. The extra leg generally creates a large area of vehicular conflict and reduces intersection capacity. Where economically feasible, the corrective measure indicated is to restrict or seal off access to the intersection and realign one leg to form another right-angled “T” intersection. This “T” intersection should be located at a sufficient distance to prevent interference with the main intersection. This realignment then permits the main intersection to be treated as a normal 4-leg intersection. Another treatment would be to channelize the intersection. This subject is covered under Subsection E 657.2.

5. Intersection E is an example of a sharply-angled intersection. The suggested improvement of the alignment is to introduce a large-radius curve to eliminate or reduce the effects of the curb protrusion into the path of an oncoming vehicle. It provides a more logical path for vehicles to follow.

E 657.2 Channelization: At-grade intersections having large paved areas, such as those with large corner radii and those at oblique angle crossings, permit and encourage uncontrolled vehicle movements, require long pedestrian crossings, and have unused pavement areas. Even at a simple intersection there may be appreciable areas on which some vehicles can wander from the natural and expected paths. Conflicts may be reduced in extent and intensity by including islands in the design layout. An at-grade intersection in which traffic is directed into definite paths by islands is termed a channelized intersection. Channelization is generally included in intersection design for the following purposes:

1. Separation of conflicts.
2. Control of angles of potential conflict.
3. Reduction of excessively large pavement areas.
4. Regulation of traffic flow and indication of proper use of an intersection.
5. Favoring of the predominant turning movement.

6. Protection of pedestrians.
7. Protection and storage of turning and crossing vehicles.
8. Providing a location for traffic control devices.
9. Discouraging or prohibiting specific movements.
10. Control of speed.

E 657.21 Principles of Channelization: The outline of the principles of channelization that follows is based on the Highway Research Board Special Report No. 74. See Section E 020F(4b). The titled cases that are shown on Figure E 657.21(1) and (2) illustrate some of the typical channelization patterns that are used for different types of intersections and are discussed below:

1. The relative speed and impact energy of intersecting vehicles are functions of vehicle speeds and angle of intersection. The impact energy varies as the square of the speed. The impact energy of the colliding vehicles in the diagram of Case Ibb is 33 times more than in Case Ia.

2. Channelization reduces the area of conflict. Large paved intersectional areas permit less control of vehicle and pedestrian movements. This lack of control may increase accidents and congestion and reduce the operating efficiency of the intersection. The diagram of Case IIa and Case IIb illustrates the differences in impact areas between channelized and nonchannelized intersections.

3. When traffic streams cross without merging and weaving, the crossing should be made at or near right angles. This angle improves the position for maneuvering or making a change of speed which may be required to avoid conflict. The intersection of traffic streams under this condition tends to:

a. Reduce the impact area.
b. Reduce the crossing time on the opposing traffic stream.
c. Reduce the conflict area size.
d. Provide the most favorable angle for drivers to judge the relative position and relative speed of intersecting vehicles.
The diagram of Case IIIa illustrates the acute-angled intersection and Case IIIb illustrates the right-angled effect created by channelization.

4. Vehicles entering a moving traffic stream at flat angles have a better opportunity to select safe gaps for entering and merging in the stream. Vehicles entering a moving traffic stream at angles greater than 10 degrees to 15 degrees must usually be subjected to stop control. This greater angle reduces the capacity and safety of the intersection because a greater time gap in the moving stream is required for the entrance of a stopped vehicle as compared to the entrance of a moving vehicle. Traffic streams should merge at small angles, as illustrated in the diagram of Case IV.

5. Channelization can provide refuge for turning and crossing vehicles of an uncontrolled traffic stream. This may also provide for safer crossing of two or more traffic streams, since the drivers need not select a safe time gap for more than one traffic stream at a time. The shadowed area illustrated in the diagram of Case V provides refuge for a vehicle waiting to cross or enter the traffic stream.

6. Funneling subordinates traffic movements to a single lane. It is generally desirable to regulate minor traffic movements to a single lane where they enter a moving traffic stream. The mouth of a separate turning lane should be flared or widened to facilitate easy entrance and then narrowed to a single lane. If properly designed, funneling discourages undesirable overtaking and passing in a conflict area. Funneling must be made readily apparent to the driver. The diagram of Case VI illustrates traffic funneling.

7. Islands are used to divert traffic streams to the permitted directions. This discourages drivers from making prohibited turns and going in the wrong direction on one-way streets. The diagram of Case VII illustrates how channelization blocks prohibited turns.

8. Channelization is usually required at complex intersections that have many turning movements. The islands also serve as locations for the installation of required traffic control devices. The diagram of Case VIII illustrates the use of channelization which provides locations for these traffic control devices.

9. Channelization separates and clearly defines points of conflict within the intersection. This permits drivers to be exposed to only one conflict and one decision at a time. The diagram of Case IX illustrates how channelization separates these conflict points.

10. Channelization must be provided at signalized intersections with complex turning movements. This permits the sorting of the approaching traffic which may move through the intersection during separate signal intervals. It is also of particular importance when traffic-actuated signal controls are employed. The diagram of Case X illustrates the type of signal control that may be necessary at intersections with these movements.

E 657.22 Channelization Design Considerations:
In designing channelization, the following points should be considered in addition to the other factors covered in Section E 650.

1. Be sure channelization is necessary.

2. Avoid isolated channelization unless of major proportions.

3. Avoid multiple maneuvers, such as merging three movements into one, or one movement offering three or more simultaneous choices.

4. Be sure islands are readily visible on approaches.

5. Where possible, a few large islands should be used rather than numerous small ones. Raised portions of islands should be offset from the edge of the traveled vehicular paths.

E 657.3 Traffic Islands: These are used to protect vehicles and pedestrians as well as to regulate their movements. They are also used for the location and protection of various types of traffic signs and other traffic devices. Where the prime objective of the traffic island is vehicular guidance and not protection of pedestrians or traffic devices, painted guide lines should be used. Pedestrian islands should be used only on exceptionally wide roadways or in large or irregularly shaped intersections where heavy volumes of vehicular traffic make it difficult and dangerous for pedestrians to cross, and should be so located as not to create a hazard for motor vehicles.

Traffic islands designated for vehicular control are classified into two separate types:
1. Divisional islands, which serve to separate traffic moving in the same or opposite directions. See Section E 460, Medians.

2. Channelizing islands, which are designed to confine specific traffic movements in definite channels.

An island may be delineated by paint, raised bars, buttons, curbs, pavement edge, or guide posts.

Vertical curbs should be used for the protection of pedestrians or physical installations and/or traffic islands. Mountable curbs are intended to permit emergency and out-of-control vehicles to cross over or mount the median. Some damage to landscaping is to be expected, but should occur infrequently. The type and function of the curb discussed above are also covered in Section E 430, Curbs.

Traffic islands should have an absolute minimum area of 50 square feet and a desirable minimum of 75 square feet. The approach end of the island should be designed with an offset to give a desired vehicle path and should be so delineated that it does not surprise the motorist.

It is the City's practice to provide gutters with a minimum width of 1 foot around islands where possible. However, where water flow is anticipated, 2-foot gutters are provided. See Section E 430, Curbs.

**E 657.31 Surfacing:** The entire raised surface of a curved traffic island should be paved with PCC. See Subsection E 467.2, Structural Cross-Section. However, consideration should be given to the landscaping of the island. See Subsection E 467.3, Landscaping. Where the landscaped islands are also used as pedestrian refuges in crossing streets, sidewalks should be provided. The sidewalks should be of PCC at least 3 inches thick and at least 4 feet wide.

Some islands are constructed by doweling or extruding curb onto the existing roadway surface. Where the resulting raised island area is 1000 square feet or less, for economical reasons the space between the existing roadway surface and the proposed raised island surface should be poured solid with PCC. In general, where the area of the island is more than 1000 square feet, the raised surface should be paved with PCC 3 inches thick. The subbase required for the roadway surfac face should also be used under the median surfacing.

In designing the raised island surfacing, cross sections should be plotted through critical sections. Surface pavement elevations should be designed to ensure surface drainage of storm waters. A minimum grade of 1 percent slope should be provided.

**E 657.4 Flared Intersections:** An intersection is generally considered flared when the normal or prevailing roadway width is increased by an additional traffic lane at the approaches to the intersection and at one or more of its legs. This provides additional capacity for through and turning movements.

The selection of a particular intersection to be flared is based on relative traffic volumes, turning movements, type of traffic controls anticipated, etc. The type and standards used by the City for the layout of the flared intersection are shown on Figures E 464.2B, Striping Standards for Secondary Highways, Plates I and II, and E 464.2C, Diamond Interchange for Major and Secondary Highways.

**E 658 SURVELEVATION RATES AT INTERSECTIONS**

The general factors which control the maximum rates of superelevation for highways also apply to intersection curves. See Section E 311, Superelevation. The desirable maximum for City streets is .06 foot per foot.

Due to right of way costs and other existing criteria, particularly on City streets within the intersection areas, the alignment limitations restrict the length of curves and radii that can be used. The amount of superelevation should be considered individually for each intersection. Indications of some conflicting situations are discussed below.

The driver will tend to slow the vehicle at intersections, particularly where other traffic is present. However, it is not a good practice to reduce the superelevation in anticipation of this, because frequently when no traffic is present, the driver may tend to continue at a normal rate. It is desirable to provide as much superelevation as practicable on intersection curves, especially
where the intersection curve is sharp and on the downgrade. However, in considering turning movements around a corner, it must be recognized that the curb return radii are relatively short in comparison to the curve radii normally used at other than intersections. In addition, superelevation which is designed for turning around a corner in one direction may provide adverse superelevation when entering from another direction. Therefore, the amount of superelevation given for a turning movement should also include the other probable turning movements before a superelevation value is assigned.

Another factor that affects the amount of superelevation to be used is drainage control. Where horizontal curves require superelevation at an intersection, and where this intersection is at or near the summit of a vertical curve, there is usually insufficient water in the street to create a drainage problem. Where this same compensating factor is applied to a sag vertical curve or to a portion of a street carrying large amounts of water, even a small amount of superelevation may direct an appreciable amount of water either to the low side or down a street with a low water-carrying capacity. This may cause property damage or may necessitate an expensive drainage system.

**E 659 SIGHT DISTANCE AT INTERSECTIONS**

The general factors which control the sight distance for highways apply also to sight distances at intersections. See Section E 340, Sight Distance. All approaches to a highway intersection at grade should permit the driver approaching the intersection to have an open view of all points at a sufficient distance to permit control of the vehicle and to avoid collision before reaching an unexpected obstacle. Where signs or signals control traffic at an intersection, the sight distance to the traffic control from an approaching vehicle is sometimes used as a sight distance control. While a right-angle crossing is desired, some deviation is permissible. Angles greater than 60 degrees produce only a small reduction in visibility, while angles smaller than 60 degrees produce a skewed-angled intersection with greater reduction in visibility.

At signalized intersections, special provisions need not normally be made for sight distance except that the signals should be visible from adequate distances. However, since burned out bulbs or power failures may make a signal control ineffective at times, and since it is possible that a disabled car or other obstruction may be in the intersection despite the "Go" signal, it is desirable to provide the same sight distance criteria as applied to stop sign control.

Adequate vertical sight distance is also vital at streets intersecting at sag and summit curves. It is important where physical separations, islands, or other channelization devices are used. Warning signs or other warning devices are desirable but should be depended upon only where corrective sight distance measures are impractical.

Care should be taken to avoid the creation of an illusion at an intersection approach. For example, a traffic circle might not be seen in advance if it is in a small dip in the profile; to a motorist approaching the intersection the road might appear to go straight through. This illusion is sometimes strengthened if a utility pole line runs straight through the intersection or at night if the headlights of approaching traffic are directly ahead.

**E 659.1 Right-Angled Intersections:** Figure E 659.1, Plate I, illustrates the minimum sight triangle which should be clear of obstructions where there is no stop or signal control at the intersection. Ideally, the distances $d_a$ and $d_b$ should be equal to the minimum stopping sight distances for the respective design speeds of the two vehicles. Where it is not economically feasible to remove an obstruction to the sight line, the speed on one of the streets may be regulated by appropriate signing. Assuming that vehicle A on the primary street is traveling at the design speed of that street, then by using the formulas in Section E 342, Safe Stopping Distances, the stopping distance $d_a$ for vehicle A can be determined. The critical stopping distance of vehicle B can be evaluated in terms of the distances to the known obstruction in the line of sight. The triangle proportion in this case is:

$$d_b = \frac{od_a}{d_a - b}$$

Where $a$, $b$ = Known distances to the obstruction in the line of sight (measured from the paths of vehicle $A$ and vehicle $B$).
By using the formula for the safe stopping distance as covered above, the corresponding safe speed for the calculated minimum distance available for vehicle B to stop can be determined. The design speed of vehicle A is known \(V_a\) and the distances to the sight obstruction from the respective paths of vehicles A and B are known \(d_a\) and \(d_b\). The critical speed \(V_b\) can be evaluated in terms of these known factors. Distance \(d_a\) is the minimum stopping distance for vehicle A. When vehicle A is at a distance \(d_a\) from the intersection and the drivers of vehicles A and B first sight each other, vehicle B is at a distance of \(d_b\) from the intersection. By the use of the triangle proportion above, the critical speed of \(V_b\) is that for which the stopping distance is \(d_b\). Therefore the proportion to use in this case is:

\[
\frac{V_a}{V_b} = \frac{d_a}{d_b}
\]

or

\[
V_b = \frac{V_a d_b}{d_a}
\]

rounded off to the nearest 5 miles per hour and the nearest 25 feet.

Where \(V_a\) = Design speed of vehicle A in mph (primary street).

\(V_b\) = Critical speed of vehicle B in mph (minor street).

The signs on the minor street showing the speed with which to approach the intersection should be so located that the driver of vehicle B can reduce his speed to \(V_b\) by the time he reaches the point that is at a distance \(d_a\) from the intersection. Similar calculations may be used to determine how far back an obstruction need be moved to provide sufficient sight distance for driving at desired vehicle speeds on the respective streets.

E 659.2 Skew-Angled Intersection: The effect of skew in the angle of intersection (less than 60 degrees) on the sight distance is illustrated in Figure E 659.1, Plate II. Where obstructions at oblique intersections limit sight distance, the distances \(a\) and \(b\) in the calculations in Subsection E 659.1 should be measured parallel to the intersecting streets.

E 659.3 Stop Control Devices: At cross streets controlled by stop or yield signs, as illustrated on Figure E 659.1, Plate III, sufficient sight distance at the intersections should be provided to permit safe crossing of the primary street. The driver of a stopped vehicle should see enough of the primary street to be able to cross before a vehicle on the primary street reaches the intersection. The required sight distance along the primary street can be expressed as:

\[
d = 1.47V t_a
\]

Where \(d\) = Minimum sight distance along the primary street from the intersection, in feet.

\(V\) = Design speed on the primary street, in miles per hour.

\(t_a\) = Time required to accelerate and traverse the distance \(S\), in seconds.

For \(t_a\), reference is made to the graph shown on Figure E 659.3, below.
E 660 REMODELING IMPROVED STREETS

Basically, a street may be reestablished (in whole or in part) by means of resurfacing the existing pavement section or reconstructing a new one. Resurfacing and reconstruction projects are generally limited to the pavement and gutter. Where it is necessary to raise or lower the flow line, the change is made only to an extent that permits the curbs to remain undisturbed. Where grades of $\frac{1}{2}$-percent or less are encountered, concrete gutters should be constructed as part of the project. The following material will serve as a guide to determine whether the project should be resurfaced, reconstructed, or both. It will also provide the basic design criteria that should be followed once the type of improvement is decided upon. See Figures E 660A, B, and C.

E 662 RESURFACING

Resurfacing is the process of covering over existing pavement with a new pavement surface. Total resurfacing is used under the following circumstances:

1. It is economically feasible, and practical from the construction standpoint, to leave all or a greater part of the existing pavement in place.

2. The existing grade, structural section, and supporting material are of such condition, thickness, etc., as to permit the existing pavement to be covered. Only such unsatisfactory or surplus portions of pavement are either completely removed or partially removed (by burning) as are deemed necessary to bring the grades and cross-sections to acceptable standards.

Partial resurfacing and partial reconstruction are generally used in conjunction with each other in many projects. Considering previously outlined guide lines, reconstruction is done on those portions of existing pavement that do not lend themselves to resurfacing. The final decision as to the proportions of resurfacing and reconstruction is based on maintaining a balance between economy and adequate design. For example, in making a design investigation, extensive resurfacing or reconstruction should not necessarily be required if the existing pavement surface elevations, for a given area, do not conform by a few hundredths of a foot to the City's design standards.

E 662.1 Design Criteria (for Resurfacing): In a street where the surfacing has deteriorated, where the crown of the street is excessively high, or where a combination of these two conditions exists, it becomes necessary to resurface the existing pavement. From soil samples and core tests (or other records that indicate the pavement thickness), it can be determined whether pavement failure was due to poor subsoil, inadequate pavement thickness, or a combination of both. If either or both of these conditions exist, refer to Section E 422, Pavement Design (Structural), and Figure E 421.1. If adding sufficient pavement to provide the required thickness does not result in excessive crown, additional pavement is merely added to the top of the existing pavement. If the additional required thickness to be added would result in too
high a crown, the existing pavement is removed. If there is poor subsoil, a sufficient depth is excavated and replaced by the recommended thickness of select material subbase. In some streets where the existing subsoil provides a good subbase and the existing pavement is of sufficient thickness, part of the pavement is removed by burning; that is, provided that a minimum 4-inch thickness of pavement remains after burning, and that the maximum crown permitted is not exceeded by the addition of the resurfacing.

The minimum desirable thickness of a resurfacing layer should be 2 inches, with 1½ inches as an absolute minimum. A small transitional area is permitted to warp or "feather in" from the absolute minimum of 1½ inches to a 0-inch thickness at the join.

E 662.2 Resurfacing Over Rails: Some streets have existing rails which are embedded in the pavement within an abandoned railway right of way. These rails should be either removed or covered with asphalt concrete pavement. After resurfacing, the resulting pavement crown should meet the pavement crown standards as specified by the crown formulas given in Subsection E 421.1, Parabolic Crown Sections.

The desirable minimum thickness of 2 inches or an absolute minimum of 1½ inches of pavement may be used to cover the rails. If the resulting crown would be too high, the rails and a sufficient amount of pavement should be removed. This area should then be repaved with an adequate geometric and structural cross-section. See Section E 422, Pavement Design (Structural).

E 663 RECONSTRUCTION

Reconstruction projects are those that require the removal of existing pavement and, where necessary, the supporting subsoil. Consideration of the following factors may help determine the justification for total or partial reconstruction.

1. Total reconstruction:
   a. The street has a major or secondary status.
   b. It would be economically unfeasible, or impractical from a construction standpoint, after removal of all the pavement that is in unsatisfactory condition, to warrant saving the remaining pavement.

2. Partial reconstruction:
   a. A minor project or local street is involved.
   b. Sufficient pavement would remain after removal of unsatisfactory pavement to make it feasible, both economically and from the construction standpoint, to save the remaining pavement.

In addition, the choice between partial or total reconstruction should be influenced by the fact that PCC pavement has a relatively greater permanency and a higher removal cost than AC pavement. Therefore, it would appear expedient to avoid total reconstruction of PCC-paved roadways.

E 664 GRADE DETERMINATION (STREET RESURFACING AND RECONSTRUCTION)

The determination of the grade for street resurfacing and reconstruction projects is limited by the amount of existing pavement that remains at, or close to, the original grade. In addition, except for increasing curb return radii, the existing curbs generally remain in place. Therefore, the existing top of curb grade as well as drainage are also limiting factors.

For partial resurfacing or reconstruction jobs, where the existing cross-sections are modified, usually no flow line grade change, or only a slight grade adjustment, is needed.

For total resurfacing or reconstruction, a new flow line grade may be established but will be limited as indicated above by the top of curb grade and drainage considerations. If a smooth flow line grade is developed and a uniform crown section is used, a smooth profile grade can be readily achieved.

E 664.1 In Meeting Existing Improvements: Where new grades are established, further study may be needed in meeting existing improvements that lie either between or within the intersections, and in providing drainage, particularly in flat areas.

E 664.11 Between Intersections: The drainage in flat areas may be improved by constructing an adequate pavement crown section and including concrete gutters. The concrete gutters should have an absolute minimum grade of 0.15 percent. If there is an existing gutter, it may have to be reconstructed to provide sufficient grade to drain.
Sufficient grade or "fall" between the high and low ends of the street may be achieved in the following manner:

1. Assume the existing curb remains undisturbed and has a curb face of 8 inches. If the pavement flow line is raised 3 inches at the high end of the street, giving a 5-inch curb face, and the pavement flow line is lowered 1 inch at the low end of the street, giving a 9-inch curb face, the total overall "fall" of the street is increased a total of 4 inches. The values given in this example represent the desirable minimum and maximum heights of curb face.

2. Where a drainage structure is located at the low end of the street, the warped gutter or local depression in the catch basin area is lowered as well as the approaching pavement flow line grade. If this is insufficient, it may be necessary, in addition to the above, to partially reconstruct and lower the existing catch basin, or to construct a new catch basin.

Changing of the street grade due to drainage problems or adjusting profile and cross-sections may require certain local grade adjustments to meet existing improvements. If these local grade adjustments cannot be made, the existing improvements must be remodeled, reset, or removed and replaced to meet the new grades. The facilities that are most generally encountered are driveways, roof drains, alley intersections, and manholes. The resetting of manholes is determined by other agencies, and the alley intersections are remodeled only up to a point deemed necessary to provide a smooth join. See Section E 610.

A new grade should provide a 1-inch curb face for existing driveways but, where necessary, may vary between 0 inches and 2 inches. The pavement flow line should not cover more than one-quarter of the diameter of existing roof drains. If these limits cannot be met by varying the flow line, it will be necessary to remove and reconstruct the roof drains and driveways to the new grade. Curbs and sidewalk removed for this purpose need be removed only up to the nearest joint immediately adjoining the reconstruction area.

When reconstructing longitudinal gutters, the standards for gutter hike-up must be met as indicated in Section E. 441.111, Transverse Slopes. In some cases when standards are used, the existing surfacing adjoining the gutter may not form a smooth cross-section with the proposed edge of gutter. If by varying the outer edge of gutter within the prescribed limits, a smooth cross-section cannot be produced, a portion of the existing pavement may have to be removed or resurfaced. If the pavement adjoining the outer edge of gutter will permit a smooth grade, but the pavement is broken, warped, or in unsatisfactory condition, sufficient pavement should be removed or resurfaced to produce a satisfactory cross-section. In any case, at least one foot of existing bituminous pavement adjoining a proposed new gutter should be removed to provide space for forming the gutter.

E 664.12 In Intersection Areas: In those projects where the intersection pavement remains, only that portion of pavement need be removed and reconstructed that is necessary to make a smooth join and pavement profile line. Work may be required in the intersection where it is desired to increase the curb return radii (see Subsections E 433.3, Curb Return Radii, and E 531.3, Intersection Drainage) or to remove existing cross-gutters and replace with rideovers (see Subsections E 441.3, Cross-Gutters, and E 531.32, Rideovers), or where the work done between intersections does not permit a smooth join at the intersection.

In redesigning the intersection, the proposed grades should be plotted indicating the flow line, quarter line, and centerline of the street. These lines are produced across the intersection and the flow lines are also extended around the curb return. If the resulting riding lines and drainage are not satisfactory, it may be necessary to readjust the grades of the remodeled street as it enters the intersection, remove additional pavement from the legs of the intersecting streets, or both.
The principal reasons for realigning and/or widening streets previously improved are:

1. The need for redesigning the existing alignment to reduce accidents or increase the efficiency of traffic movements.

2. The necessity for meeting the street or highway standards of various ordinances or codes, such as Highway Dedication and Improvement (R-3), Subdivision, and Parcel map; also those standards due to zone changes and conditional uses. This necessity may be the result of private development by permits, Council Resolution, or assessment proceedings.

3. The need for projects included in the Five Year Capital Program to conform to the width and alignment requirements of streets designated as major or secondary highways of the City’s Master Plan of Highways and Freeways and to those shown on Figure E 113, Standard Street Dimensions.

4. The necessity for modifying a street pattern as a result of a major project, such as a freeway, a grade separation, Urban Renewal Development, Community Redevelopment, etc. Figure E 670 shows typical sections of streets that are to be widened and some of the affected component parts.

The design particulars for realignment and/or widening of improved streets are covered by the standards presented throughout this Part of the Manual and by the discussions that follow.

### E 671 INTERFERENCE OF EXISTING IMPROVEMENTS

In processing projects involving the realignment and widening of improved streets, it will be found that if some of the existing improvements are left in place or not modified in some manner, they may interfere with construction or with vehicular and pedestrian traffic. The types of existing improvements usually involved are either publicly or privately owned and may be located on the public way or on private property. Public property, “public” being used in a broad sense, may be divided into two categories: public facilities and public utilities. Public facilities include pavement, curbs, gutters, sidewalks, driveway approaches, etc. The removal and reconstruction of pavement have been presented in Section E 660. The remaining facilities have been covered under their respective titles elsewhere in this Part of the Manual. The removal and relocation of public utilities, such as power and telephone poles, cables, and gas, oil, and water lines have in part been covered under Subsection E 052.31, Prior Rights. The procedures for their removal are covered under Sections E 810, Assessment Act Projects (Street Improvements Under 1911 Act and 1941 Ordinances), and E 820, Capital Improvement Projects (C.I.P.), and the other criteria for their removal and relocation under Subsection E 671.1. The City’s policies covering removal of private improvements on public streets and on private property are discussed under Sections E 050, Fundamentals of Real Property for Street Design Purposes, and E 130, Street Improvement Policies, and procedurally under Sections E 810 and E 820, as stated above. Other related material is covered elsewhere in this Part of the Manual and in Subsections E 671.2 and E 671.3. Special reference in connection with all removals is made in the Standard Specifications — 1970 Edition. See Section E 020B.

In some cases, the removal or relocation of existing public utilities or private improvements may be contemplated. These utilities or improvements may be on private property or may encroach on the public way. In such cases, the criteria outlined under Standard Specifications — 1970 Edition and the material in this Part of the Manual should be used as a guide. If, in the design supervisor’s opinion, the location or encroachment does not materially affect the construction or the design, and does not create any unsafe conditions with possible consequent liability of the City, the improvement may remain in place. This is true particularly where a relatively major improvement is involved.

**E 671.1 Public Improvements Within the Street or Alley:** In general, the removal and relocation of utilities are due to realignment or grade changes in streets and alleys. Particularly where utility companies have prior rights, it should be recognized that the cost of the relocation and removal may have to be borne directly by the assessment district on assessment projects and by the taxpayers on capital improvement projects.
The street designer will be concerned primarily with the interference and removal or relocation of surface utilities. Existing manholes, transformers, vaults, water meters, etc., that are required to remain in the plane of the pavement are reset to grade.

Where curbs are to be realigned in streets, utility poles may not be located closer than 6 inches from the back of the top of the curb. In alleys, the need for the removal or relocation of utility poles is determined by the width of the alley and the location of the poles with respect to the alley property line. The pole offset from the nearest property line is the distance measured from the farthestmost face of the pole to the property line. Utility poles in an alley 15 feet wide or less should be relocated when the distance to which they extend into the alley is greater than 18 inches. Poles in alleys more than 15 feet wide should be relocated when the distance to which they extend into the alley is greater than 10 percent of the alley width. In no case should they extend more than 2 feet.

E 671.2 Private Improvements Within the Street or Alley: Where encroaching private improvements extend into an alley more than 3 inches, it is a general policy to remove them in the case of pavement or to relocate them to the property line in the case of fences. Concrete slabs in good condition, or relatively new or substantial fences, walls, structures, etc., may be permitted, at the discretion of the design supervisor, to extend more than 3 inches into the alley. However, the concrete pavement must not conflict with the proposed alley grades or cross-sections, and the width of alley (horizontal clearance) should not be materially affected in the case of the other existing improvements. An example of an impaired clearance is where two existing fences, walls, buildings, etc., are located directly across from each other in an alley, and where the two extend into the alley more than 3 inches from the property line. Refer also to Section E 452, Sidewalks. Any existing improvements, whether in a street or in an alley, may be removed, regardless of the degree of encroachment, if permitting them to remain in place would create a dangerous or unsightly condition, unduly sacrifice design standards, or result in excessive construction or maintenance costs.

If, however, the right of way agent or the coordinating designer indicates that the owners are not cooperative, or are indecisive, or that the meeting is not advisable, the designer should obtain approval from his supervising engineer for elimination of the conference. In cases where determination of the owner's feelings is not established, the designer should discuss the conditions and problems with the right of way agent and any others involved to determine the best course of action. Following this, clearance for the final course of action should be obtained from the supervising engineer. In making these decisions regarding the course of action, it should be kept in mind that unless we are sure of the owner's viewpoint, we should keep the amount of replacement minimized by replacing only those facilities necessary for the use and safety of the property, or by making replacements which are obviously desirable for esthetic reasons.

This policy should not be construed as advocating compliance with unreasonable or illegal requests by the owner. For example, requests such as those given in the following list should be tactfully but firmly denied:

1. Replacement of an illegal-height fence in a front yard.
2. Replacements which are considerably greater in magnitude than the original facilities.
3. Replacements which are not in accord with the overall esthetic appearance of the project, even though they may be similar to the existing facilities in construction or materials.

Some of the design and other criteria for the alterations of existing improvements may come under the jurisdiction of other departments or agencies. Where possible, and in conformance with the above policy and procedure, it may be expedient to set the grades and alignment so that in adjusting the private improvements on private property the standards of these various offices can be met. With this in view, driveway standards to meet the Department of Building and Safety requirements have been covered under Subsection E 635.3. Some other standards for revamping existing improvements are covered in the following subsections.

E 671.3 Private Improvements on Private Property: On many projects, construction of new im-
Improvements necessitates the removal of certain existing privately owned auxiliary improvements located on private property, such as fences, garden walls, retaining walls, planters, stairways, etc. In those cases, the designer is usually confronted with many problems in deciding whether the project plans should provide for replacement and re-location of these facilities. This is because of two possible situations that may arise. In one case, replacement is not actually necessary to allow for the new improvements, but is desired by the owner. In the other case, replacement is necessary or advisable, especially in connection with safety, access, or the usefulness of the property, and several solutions in regard to location, materials, etc., are available. In such situations, the office policy should conform to the following:

1. Initially the designer should discuss the conditions and problems with the supervising engineer. Upon approval of the supervisor, a conference should be arranged to determine the owner's attitude in this matter. In regard to these conferences, no comprehensively detailed policy will be set. However, the following rules should be adhered to:

   a. A representative of the appropriate Negotiation Division of the Bureau of Right of Way and Land should always be requested to attend and approve the conference, since these are the official negotiators for the City in such matters.

   b. Whenever special legal problems concerning acquisition may be encountered, a member of the City Attorney's staff should be requested to be present.

   c. The meeting should be coordinated by the project design engineer in the office responsible for the coordination of the project. Following these conferences, the matter should be discussed further with the supervising engineer, with a view to designing the project in accordance with the owner's requests whenever it is reasonable to do so.

**E 671.31 Walls and Fences:** For the purposes of this Part of the Manual, a retaining wall is defined as a structure that serves to hold backfill or surcharge and requires the designing of these structures by a registered structural engineer. All retaining walls 4 feet in height, including the footing, or walls of any height with sloping backfill or surcharge require this design. The Bridge and Structural Design Division is the only division that has the necessary personnel for the designing of walls by the Department of Public Works.

A wood or other nonmasonry fence merely serves as a boundary or line of demarcation and does not necessarily require an engineered design. However, concrete or masonry fences over 6 feet in height, including the footing, or fences other than concrete or masonry over 10 feet in height require an engineered design.

It is usually necessary to secure an easement for the construction of a wall to retain and support private property adjoining a street widening project. Therefore, where a retaining wall or bulkhead is to be constructed longitudinally along a new street widening project, the responsible design office should delineate the limits of the wall or bulkhead on the right of way sketch accompanying the request for the appropriate type of right of way acquisition. See also Section E 470, Retaining Walls and Bulkheads.

**E 671.32 Housewalks and Steps:** Housewalks are sidewalks generally on private property and generally perpendicular to the public sidewalk, which is located on public property. They may be constructed independently or as part of the driveway and may be of asphalt concrete or concrete pavement. Where housewalks have to be reconstructed, the maximum longitudinal slope of the housewalk or ramp without handrails is 10 percent. Where this slope exceeds 10 percent but not 12 1/2 percent, handrails are required. Where it exceeds 12 1/2 percent, steps should be substituted for the ramp or housewalk. Where steps are reconstructed, the minimum width of tread should be 10 inches, the maximum riser 7 1/2 inches, and the minimum riser 4 inches.

For further details, such as landings and other related requirements, refer to the Municipal Code, Chapter IX, Building Regulations. See Section E 020A.

**E 671.33 Side Slopes:** In cases where slope easements with cuts or fills of 6 inches or more are required, the right of way sketch should show this information at each new temporary or permanent property corner and at the intermediate points. See Figures E 823A(1) and E 823A(2). Request to Acquire Final Right of Way — C.I.P.
Street Projects Only, Sheets 1 and 2 respectively, and E 823B, Typical Final Sketch. See also Section E 481, Side Slope Design Requirements, and Subsections E 054.23, Easements, and E 823.1, Temporary or Permanent Rights in Private Property.

**E 671.4 Tree Removals:** Many hillside streets and other projects involving changes of street width, grade, and alignment may necessitate removal of trees that are on private or public property. At present, the City Policy is to replace all trees on public property that are removed. Plans requiring tree removal should be reviewed and approved by the City Beautification Coordinator of the Department of Public Works. In addition, it may be well to coordinate tree removal and replacement with the Councilman of the district in which the improvement is contemplated.

If possible, minor local grading modifications should be considered to avoid tree removal. The proposed grading of slopes and its effect on adjacent trees and their root systems should be carefully evaluated. Where necessary, a representative from the Street Tree Division of the Bureau of Street Maintenance should determine whether or not a tree may safely remain in place. Where widening is to be on one side of the street as opposed to both sides, the designer should consider the additional cost of tree removal and replacement.
E 680 PRIVATE STREETS

The increased filing of maps showing private streets as part of a planned residential development or condominium has necessitated a determination of policy in regard to the use of private streets and the application of the Private Street Regulation in the Municipal Code, Chapter I, Article 8. See E 02OA. Experience of the Bureau of Engineering and other City departments indicates that approval of private streets should be discouraged for the following reasons:

1. Private streets usually include substandard improvements.

2. The private road easements are narrow, resulting in substandard roadway widths.

3. The private street area may be utilized in the computation of lot areas of adjoining properties, which results in substandard lot sizes.

4. Various City Departments, such as Fire, Police, Water and Power, and Public Works object to their service vehicles having to travel on private streets for legal as well as physical reasons.

5. Purchasers of lots fronting on private streets are often unaware that they are responsible for the maintenance of the street.

6. Private streets restrict the development of adjacent areas which require access to public streets.

7. The use of a private street with a condominium development is a violation of the Municipal Code, since the definition of a private street presumes more than one ownership.

8. Private streets combined with public streets in a tract result in complications and questionable legality when enforcing completion of improvements under improvement bonds.

E 681 DESIGN STANDARDS

The following conditions should govern the recommendations for private streets, including those private streets lying within subdivisions or condominium developments and those filed in conjunction with parcel maps:

1. General — No private street should be approved unless the Division or District Engineer determines that due to problems of usage, topography, geology, property development, or other considerations the dedication of a public street would be unreasonable, impractical, or undesirable and there is no alternative to the private street.

2. Future Public Street — If it is determined that the private street may become a part of the public street system in the area and that future dedication as a public street may be desirable, the width of the private road easement lying within the property should conform to the current standard street design appropriate for the anticipated use. See Section E 110, Street Classifications. In addition, the property owners should record an agreement to the effect that:

   a. They will join in any future dedication and improvement to the private street or alley as a public street or alley to the extent of their interest therein.

   b. They will do this either when the adjoining property owners agree to dedicate and improve or when so requested by the City.

   c. Any subsequent sales of the property will be conditioned upon this agreement.

3. Side Slopes — Adequate cut or fill slopes conforming to standards which are acceptable for slopes adjacent to public streets should be provided as a part of the grading of the private street.

4. Minimum Improvement — The minimum improvement of a private street, except as covered in condition 7, below, should be as set forth in the Municipal Code, Chapter I, Article 8, Section 17.05E for alleys, including a roadway width of 20 feet, a 2-foot concrete longitudinal gutter, and a 4-inch thickness of asphalt concrete paving unless otherwise permitted or required by the City Engineer. Concrete curbs and gutters or extruded asphalt concrete curbs are required where safety or drainage is a factor. Guard rails and warning signs are required when deemed advisable for safety. These improvements will bring the street up to the standards required for use by City vehicles, such as fire engines, garbage trucks, etc.

5. "B" Permit Requirement — This type of improvement should meet the requirements of the Municipal Code, Chapter I, Article 8, and should be constructed under "B" Permit in accordance with Section 18.05 of this article.
6. Right of Entry — In the event that a private street is accompanied by an improvement bond, the property owner should record an agreement, to go with the land, granting the City or its agents and the bond surety or its agents the right to enter upon any private property when necessary to complete any and all improvements in the private street in the event of default by the owner. The agreement should also contain a waiver of any damages which may result from the entry necessary to complete these improvements, and should be included as a statement in the certificate of dedication on the tract map or recorded as a separate instrument in the absence of a tract map. This grant of authority terminates upon completion of the improvements and their acceptance by the City. This agreement is not required in the absence of an improvement bond.

7. Driveway Only — If the private street is approved only for driveway access to no more than two parcels, and will not be used by City vehicles, the improvement may be accomplished in accordance with the Municipal Code, Chapter I, Article 8, Section 12.21, Subsections A4(h) and A6(d).