CITY OF ANAHEIM

SUBDIVISION SECTION
STREET DESIGN MANUAL

Design Sample of Structural Section

A. INTRODUCTION - POLICY STATEMENT

The City of Anaheim provides this design procedure manual for use as a guide for all consulting engineers submitting street improvement plans. These procedures are intended to provide guidance in the design of new and/or reconstruction of existing public and private streets and roadways dedicated to the City of Anaheim as well as to facilities located in private developments.

This guide is to be used in conjunction with City of Anaheim Engineering Standards and Policies, Orange County Highway Design Manual, and the State of California Department of Transportation (Caltrans) Highway Design Manual. It is not intended to be a substitute for any of the above mentioned manuals or for the design and care of engineering practice, but to provide guidance from adopted standards and manuals for new and existing improvements.

The accuracy, sound design, and conformance with accepted engineering practice of all plans submitted to the City will remain the sole responsibility of engineer-of-record.

B: STREET CLASSIFICATION:

	RIGHT OF WAY	DESIGN SPEED MPH	STD. DTL. NO.
Major Arterial	94'-102'	60	160
Primary Arterial	106'	55	160
Secondary Arterial	90'	50	160
Industrial Street	64'	35	160
Collector Street	64'	35	160
Interior Street	60'	25	160
Hillside Primary Highway	106' - 118'	55*	161
Hillside Secondary Hwy	66' - 78'	50*	161
Hillside Collector Street	37' - 49'	35	161
Hillside Interior Street	35' - 25'	25	161
Private Street		25	162

Notes:

1. See the Circulation Element and Exceptions to Arterial highway Right-of-Way of the City of Anaheim for Right-of-way of Arterial Highways.

2. See Standard Detail No. 162 for private street design.

C. STREET STANDARDS:

1. REQUIREMENTS AS SPECIFIED PER CONDITION(S)

a. Where the requirements for any developments are not specified in these standards, such requirements will be specified by the Planning Commission and/or City Council in the action approving or conditionally approving the development plan or, if not specified in such action, as required by the City Engineer.

b. Such requirements must conform to City of Anaheim Engineering Standards and Policies, City Ordinances, and development codes and local laws.

2. APPROVAL OF STREET IMPROVEMENT PLANS

a. The developer's engineer must prepare in accordance with engineering standards and submit to the City Engineer for approval plans, profiles, specifications for the proposed improvement of all public and private streets, easements, and drainage ways.

b. The developer's engineer must obtain the approval of the City Utilities Department and the City Engineer for plans, profiles, and specifications, and obtain necessary clearance and/or permits prior to commencing any construction.

c. Performance Improvement Bond and Labor and Material Bond shall be submitted and posted for any public improvement(s) to be constructed within the city right-of-way or public easement and/or to include any development fees required and approved by the City Council.

d. The developer shall submit Subdivision Agreements for the construction or reconstruction of public improvements within the city right-of-way or public easement in conjunction with a parcel map or tract map conditions of approval. Subdivision Agreements shall be approved by the City Attorney and the City Council.

3. PAYMENT FOR IMPROVEMENT

a. All improvements required by the conditions of approval or by the City Engineer must be constructed and installed by the developer at his expense unless otherwise expressly specified and conveyed to the City upon final acceptance of the improvements by the City of Anaheim.

4. WIDENING AND IMPROVEMENT OF EXISTING STREETS

Where land abutting an existing substandard street or road is subdivided or developed in any other way, the following shall apply:

a. The developer shall be required to dedicate any necessary right-of-way to conform to General Plan.

b. The developer may be required to improve such streets to conform to General Plan Specifications and be applicable to City Standards and approved plans.

c. In all developments including land divisions, the developer or owner may be required to dedicate any necessary additional right-of-way adjacent to or within the development.

5. DESIGN OF STREET SYSTEM

The design of street systems including right-of-way and improvement widths, must provide the following:

a. Adequate local service for the area being developed.

b. Consistency with the City's General Plan Circulation Element where applicable.

c. Adequate capacity for all anticipated future development in the area.

6. DESIGN AND INSTALLATION OF UTILITIES

a. All utilities must be installed in accordance with applicable city utility standards and state laws. All locations must be coordinated in the design phase with the City of Anaheim Utility Department and must be shown on all construction plans.

b. Approval by the Utilities Department is required as well as any conditions mandated upon development.

7. STREET NAME SIGNS

a. The developer must install street name signs as part of the improvements. Street names must be approved by the Planning Department and street name's signs must be installed per City Standard No. 425.

8. TRAFFIC SIGNS

a. The developer must install all necessary traffic regulatory and warning signs specified by the City Traffic Engineer and City Engineer as part of the street improvements.

9. TRAFFIC ENGINEERING PLANS

a. Traffic striping plans if required shall be submitted together with street improvements. All striping shall be constructed in accordance with city and state standards and shall be approved by the City Traffic Engineer.

b. Traffic and signal plans if be required as per conditions of approval for the development shall be submitted to the Traffic Engineering for review and approval.

10. DETOUR PLANS

Any detour plans required by the City Traffic Manager shall be submitted and approved by the Traffic Division prior to issuance of the right of way construction permit.

11. RIGHT-OF-WAY DEDICATION

a. Property corner cut off for additional right-of-way for access ramp may be required.

b. Additional right-of-way dedication may be required per the City's General Circulation Element.

c. When additional right-of-way is required, a right-of-way sketch and legal description indicating dedication shall be shown and processed through the Real Property Section. Once a dedication sketch and legal description has been approved and executed by Real Properties, City Council will make a final approval of the dedication.

D. GEOMETRIC DESIGN:

1. GRADES

Minimum requirements on all street improvement plans shall have the following criteria to establish grades:

	Flatland	Hillside
Street crossfall:	2% Min.(*)	2% Min (*)

Rate of Grade:	R=0.2% Min.	R=0.2% Min.; 10% Max
Cross Gutter:	R=0.2% Min.	R=0.2% Min.
Curved Curbs:	R=0.4% Min.	R=0.4% Min.
Cul-de-Sacs:	R=0.4% Min.	R=0.4% Min.
Hillside X-Gutter (see detail 2 for calculations)		R=5% Min.
Curb Return Radius: For Local Streets	25 feet Min.	25 feet Min.
For Arterials	35 feet Min.	35 feet Min.

(*) 5% maximum (to join the existing pavement).

a. 0.5% maximum longitudinal grade break on centerline and curb line (without going to vertical curve).

b. When joining curb and gutter where curbs are being constructed, transitioning from 6" curb to an 8" curb; use 7' length span per each 1" difference in curb height.

c. The minimum curve radius for curb transitions shall be 26 feet. When transitioning street width; use reverse curves of R=26' for width difference of 2' or greater, a curb transition with a ratio of 1:20 may be acceptable if approved by the Traffic Engineer.

2. VERTICAL CURVES

Longitudinal grade break on centerline and curb lines exceeds 0.5%, vertical curve shall be used.

a. Vertical curve data shall include tangent grades, PIVC, station and elevation, and elevations at every 25 feet, high point and low point station and elevation.

b. For design speeds of 40 miles per hour or more the minimum length of vertical curve should be 400 feet. For design speeds of 30 miles per hour curves should be 200 feet. See Section 204.4 of the Caltrans Highway Design Manual.

3. SIGHT DISTANCE

Three types of sight distances are to be considered for continuous length of highway ahead visible to the driver: passing, stopping, and decision. Caltrans Highway Design Manual shall be used to determine this based on the design speed.

Sight Distance Standards - (Table 201.1 per Caltrans)
Passing Sight Distance - (Section 201.2 per Caltrans)
Stopping Sight Distance - (Section 201.3 per Caltrans)

a. at Grade Crest (Caltrans Section 201.4)
b. at Grade Sags (Caltrans Section 201.5)
c. at Horizontal Curves (Caltrans Section 201.6 and Exhibit "B")

Corner Sight Distance - (See Section 405 per Caltrans)

Corner sight distance shall be utilized for all public road intersections at unsignalized public road intersections (See Exhibit "F") a substantially clear line of sight should be maintained between the driver of a vehicle waiting at the cross road and the driver of an approaching vehicle in the right lane of the main highway.

4. SUPERELEVATION

Standards for Superelevation are based on an e(max) selected by the designer for one of the conditions, superelevation rates from Caltrans table 202.2 shall be used within the given range of curve radii (See Caltrans Section 202.2 and Exhibit "C").

5. SUPERELEVATION TRANSITION

General. The superelevation transition generally consists of the crown runoff, the superelevation runoff, and the remaining 50 feet of the vertical curve as shown on figure 202.5 (See Exhibit "D" and Caltrans Section 205.5).

6. HORIZONTAL CURVES

Horizontal alignment should provide for safe and continuous operation at a uniform design speed for substantial lengths of highway (See Caltrans Section 203.1).

Standards for Curvature:

Table 203.2 of Caltrans Highway Design Manual shall be used for minimum radius of curve for specific design speeds.

Every effort should be made to exceed minimum values, and such minimum radii should be used only when the cost or other adverse effects of realizing a higher standard are inconsistent with the benefits. The recommended minimum radii is 3000 feet in urban areas (See Exhibit "E").

7. CUL-DE-SAC STREET LENGTH

The total street length of a cul-de-sac must not be greater than 700 feet, except as approved by the City Engineer.

8. MEDIAN ISLAND

The minimum width of a landscaped median island for a public street shall be 16 feet from curb to curb as per City Standard No. 129. Private streets may vary in type, width, and shape based on City Standards 140, 141, 142 and 143.

Glued down curb can be used for median curbs if a median island is constructed on the existing pavement.

9. STREET KNUCKLES

Street knuckles shall comply to City Standard Detail No. 167. The maximum slope from the crown line to outer curb shall be 5% with a minimum 2%.

10. PRIVATE STREETS

All private streets shall comply to City Standard No. 122. Minimum grades shall be 0.2%, with a maximum of 10%, and a minimum crossfall of 2%. Street widths shall vary per development and shall comply to all City Standards.

Streets greater than 300 feet in length without outlet, must have a minimum 38 foot radius cul-de-sac per City Standard Detail No. 166.

E. STRUCTURAL SECTION:

1. TRAFFIC DATA FOR STRUCTURAL SECTION DESIGN

The primary goal of the design of the structural roadbed section is to provide a structurally stable and durable pavement and base system which, with minimum maintenance will carry the projected traffic loading for the selected design period.

2. BASEMENT SOILS (Section 604)

The resistance value (R-Value) is a parameter representing the resistance to deformation of a saturated soil under compression at a given density. The R-value is measured with the stabilometer and is used in the design of the flexible and rigid pavements. It is an indication of the ability of soil to carry the dead load of the structural section and superimposed traffic live load.

3. SUBBASES AND BASES (Caltrans Section 605)

The characteristics of various subbases and bases that may be used in structural sections are discussed in the following text. Generally, these subbases and bases may be used in various combinations to design the most economical structural section for the specific project. Standard structural sections are used for portland cement concrete pavement (PCCP) with optional base and subbase combinations.

Because different types of treated and untreated aggregates have different capacities for resisting the forces imposed by traffic, this factor must be considered when determining the thickness of the structural section elements. This is accomplished with gravel factors (Gf) which express the relative value of various materials when compared to gravel. It is important to note that the various materials must meet the specified quality requirements, such as grading, to ensure the validity of the assigned gravel factor. Gravel factors for the various types of base materials are provided in Table 605.1 (See Exhibit "J").

4. DETERMINATION OF DESIGN R-VALUE (Section 604.2)

R-values of soils to be encountered on a project are provided in the Materials Report. Considerable variation in these values within project limits is quite common. Since a design R-value must be chosen for design of the structural section, it is important to know the extent of material represented by the various R-value tests.

Since a wide variation of material types and deposits found within project limits are quite common, it is not practical to establish hard and fast rules for selecting a design R-value. Judgment based on experience should still be exercised to assure a reasonable "balanced design" which will avoid excessive costs resulting from over conservatism. Examples from the past should be used only as indicators of potentially good or bad practice.

If the range of R-value is small or if most of the values are in a narrow range with some scattered higher values, the lowest R-value should be selected for the structural section design. The lowest R-value should not, however, necessarily govern the structural section design throughout the length of long projects. If there are a few exceptionally low R-values and they represent a relatively small volume of basement soil or they are concentrated in a small area, it may be possible to specify placing this material in the bottom of an embankment or in the slope area outside the structural section limits. Occasionally a lime treatment of a short length may be cost effective.

5. FLEXIBLE PAVEMENT (Caltrans Section 608.4)

The design of the flexible pavement structural section is based on a relationship between the "gravel equivalent" (GE) of the structural section materials, the Traffic Index (TI), and the R-value (R) of the underlying material. This is presented by the equation GE = 0.0032 (TI)(100-R). This is illustrated graphically in Exhibit "I" which is used primarily to check computed values of the required GE for the total structural section and for the pavement, base, and subbase layers.

The GE requirement for the structural section can be provided by a wide variety of pavement, base, and subbase materials in various combinations of layer thicknesses that are designed primarily to spread and transmit the live load to the underlying roadbed. Base and subbase types are listed in Table 605.1 (See Exhibit "J") and discussed in Topic 605.

Asphalt Concrete pavement types are listed in Table 608.2 and discussed in Index 608.2 (See Exhibit "K").

6. BASIC RULES FOR DESIGNING FLEXIBLE PAVEMENTS

When designing flexible structural sections, the following basic rules will apply:

a. The TI is determined to the nearest 0.5.

b. The following standard design formula is applied to determine the GE of the cover required over the basement soil and intermediate structural section layers with a known or assumed R-value:

$GE = 0.0032(TI)(100-R)$

where: GE = gravel equivalent in feet
TI = traffic index
R = R-value of the material to be covered

c. The GE to be provided by each material is determined in order by layer, starting with the AC and proceeding downwards.

d. Safety factors are applied by increasing the GE of the AC by the amount indicated in index 608.4(2). An equal GE is subtracted from the subbase (base layer when there is no subbase).

The safety factor must be included when calculating the required GE of the combined AC and base material. When full depth AC is used, there may not be an underlying layer from which to subtract the safety factor GE. In these cases, a full depth AC section will slightly exceed the required cover.

e. Base and subbase materials other than ATPB (Asphalt Treated Permeable Base), should have a minimum thickness of 0.35 foot. When the calculated thickness of base or subbase material is less than the desired 0.35 foot minimum thickness, either increase the thickness to the minimum without changing the thicknesses of the overlying layers or eliminate and increase the thickness of the AC or base layer to compensate for the reduction in GE.

f. Treated permeable bases are placed in standard thicknesses of 0.25 foot of ATPB or 0.35 foot of CTPB (Cement Treated Premeable Base), (See Caltrans Index 606.2(3)).

g. The thickness of each material layer is calculated by dividing the GE by the appropriate Gf (From Caltrans Table 605.1 or 608.4, See Exhibit "L"). Note that the Gf of AC is not a constant value. As the TI increases, the Gf decreases. Also, the Gf of AC gradually increases for any given TI as the total thickness of AC increases above 0.50 foot.

The following equations can be used to calculate the Gf of asphalt concrete, but are only provided here for information:

AC Thickness (t) less than or equal to 0.50 foot:

$Gf = 5.67/(TI)^{0.5}$

AC thickness (t) greater than 0.50 foot:

$Gf = (7.00)(t)^{1/3}/(TI)^{0.5}$

Caltrans Table 608.4, Exhibit "L" should normally be used in lieu of using these equations to determine

AC thicknesses. When selecting the design layer thickness, the value is rounded to the nearest 0.05 foot. A value midway between 0.05 increments is rounded to the next higher value.

h. The design procedure provides the minimum allowable thickness of AC for the project conditions. This thickness may be increased when appropriate to minimize constructions costs, reduce construction time, match layer placement with existing adjacent lanes, reduce the number of layers, etc., provided the minimum GE and construction requirements are satisfied.

7. STREET STRUCTURAL SECTION

The minimum asphalt concrete both for private and public streets shall be 0.35' over a base material.

F. MISCELLANEOUS:

1. STATE HIGHWAYS

Access to State Highways is regulated by Caltrans. The City will coordinate requests for new access and changes to the existing access with Caltrans. Encroachment permits for access to State Highways are available from Caltrans, and it is the responsibility of the developer to obtain permits whenever construction within Caltrans' right-of-way is anticipated.

2. BIKEWAYS

Class I and Class II bikeways, when required by conditions of approval and/or per City of Anaheim General Plan, shall conform to Orange County Highway Design Manual in "The Master Plan of Countywide Bikeways" (MPCB) design criteria.

3. BUS LOADING FACILITIES

Bus loading facilities such as bus bays, turnouts, and bus shelters shall be reviewed by the City Traffic Engineer and coordinated with the Orange County Transit District (O.C.T.D.).

4. SIDEWALK

All public streets shall be designed with sidewalks per City Standard No. 110 and/or as conditions of approval prevail.

5. DRIVE APPROACHES

Drive approaches shall be designed per City Standard No. 114 for local streets and residential developments, No's 115 for arterial highways, commercial and industrial developments.

6. CURB RAMPS

Access ramps shall be designed per City Standard No. 111. A corner property cut off for additional right-of-way may be required.

7. SUPPLEMENT LANES INTERSECTIONS

Locations of critical intersections are indicated on the City General Plan Circulation Element and shall be designed per City Standard No. 164. Additional right-of-way is required.

DESIGN EXAMPLE OF STRUCTURAL SECTION

Assume design R-Value=21, and Traffic Index = 6.9

a) Calculate the GE Requirement for the structural section.

use:	GE =	0.0032 (TI) (100-R)
		0.0032 (6.9)(100-21), or use graph for relationship between Gravel Equivalent and R-Value (See Exhibit "I")
	GE=	1.74

b) Calculate the gravel factor (Gf) for the asphalt concrete.

Gf(AC) =	5.67/(TI)^0.5
	5.67/(6.9)^0.5
Gf(AC) =	2.16

c) Calculate the GE for the asphalt concrete.

GE(AC) =	0.0032 (TI)(100-R) here R is assumed
	0.0032(6.9)(100-78) to be 78 for AC
GE(AC) =	0.486

d) Divide the GE(AC) by Gf(AC) to arrive for the total AC required.

0.486 GE(AC)/2.16Gf(AC) =	0.225'
use	0.35' AC as minimum
GE (Actual) =	0.035 x 2.16 Gf(AC)
=	= 0.756'

e) Calculate the total base of the section.

Total Base =	[GE - GE(Actual)]/GE Base material
	(1.74-0.756)/1.1

*1.1 is the GE for Base Material (See Exhibit "L")

Total (Base) = 0.89'

Use 0.90'BM

Total Structural Section is **0.35' AC over 0.90'BM**