533372 Highway Engineering

Introduction to Physical Design of Transportation Facilities

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The Design Process

Planning:

The more general and abstract parts of the process

Design:

The more detailed and concrete parts of the process

The concept of design process:

"Using of rational processes to decide how to use available resources to achieve goals"

The steps of design process (1):

1. Deciding generally what sort of system or facility is needed
2. Demand analysis for the system or facility to be designed
3. Traffic performance analysis
4. Size the facility or system, based on performance standards and the traffic analysis
5. Determine the location of the facility or system
6. Determine the configuration and/or orientation of the facility or system

The steps of design process (2):

7. Identify physical design standards
8. Geometric design
9. Design auxiliary systems
10. Design surface or guideway
11. Estimate construction costs and project impacts
12. Evaluate design

Design Standards

Transportation system characteristics (or design elements) to which design standards apply include the following:

- o Minimum radius of horizontal curve
- o Maximum rate of superelevation
- o Maximum grade
- o Minimum grade
- o Minimum cross-slopes

- o Minimum length of vertical curve
- o Edge radii in roadway and taxiway intersection
- o Minimum intersection setbacks
- o Freeway ramp junction details
- o Horizontal and vertical clearances

Design Speed and Sight Distance

o Sight distance is related to the ***design speed*** of the facility

Design speed:
The maximum safe speed that can be maintained over a specified section of highway when conditions are so favorable that the design feature of the highway govern

o There are two types of sight distance:

1. Stopping sight distance:
The distance required to see an object 0.15 m high on the roadway. It is intended to allow drivers to stop safely after sighting an object on the roadway large enough to cause damage to the vehicle or loss of control

$$s = d_r + d_b$$

s = stopping sight distance, m
d_r = the distance traveled during the driver's reaction time, sec
d_b = the braking distance, m

$$d_r = vt_r$$

V = design speed

t_r = the driver's reaction time (including perception time)

= 2.5 sec *(AASHTO suggestion value in Policy on Geometric Design of Highways and Streets)*

$$d_b = \frac{v^2}{2g(f \pm G)}$$

d_b = braking distance

g = acceleration of gravity

f = coefficient of friction between tires and pavement

G = average grade, dimensionless ratio (m/m)

o For the case in which G varies, AASHTO gives the mixed unit formula:

$$d_b = \frac{V^2}{254 f}$$

d_b = braking distance, m

V = design speed, km/h

f = coefficient of friction between tires and pavement (vary with design speed)

Note: ignore the effect of grade variation

Example 1: Determine minimum stopping sight distance on a -3.5% grade for a design speed of 110 km/h.

Solution: Total required stopping sight distance

$$s = d_r + d_b$$

Reaction distance:

$$d_r = vt_r = (110\,km/h)\left(\frac{1{,}000\,m/km}{3{,}600\,s/h}\right)(2.5\,s) = 76.4\,m$$

Braking distance:

$$f = 0.28\,(Table\,3.3)$$
$$G = 0.035\,(given)$$

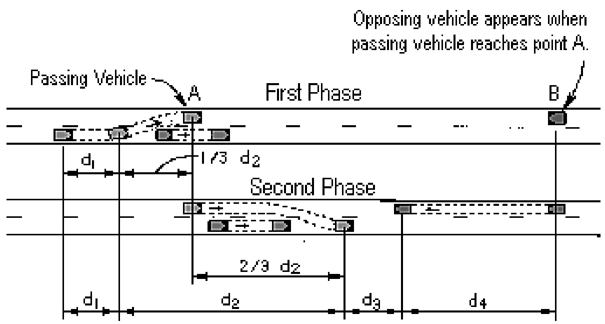
$$d_b = \frac{v^2}{2g(f \pm G)} = \frac{\left[(110\,km/m)\left(\frac{1{,}000\,m/km}{3{,}600\,s/h}\right)\right]^2}{2(9.8\,m/s^2)(0.28 - 0.035)} = 194.4\,m$$

Total sight distance:

$$s = d_r + d_b = 76.4 + 194.4 = 270.8\,m$$

2. Passing sight distance:

The distance required to see an oncoming vehicle of a certain minimum size. It is intended to ensure that a passing maneuver can be completed safely under certain assumptions as to vehicle speeds and acceleration capabilities.



o For purposes of analysis, AASHTO defines four distances:

d_1 = distance traversed during perception and reaction time and during the initial acceleration to the point of encroachment on the left lane in meters

$$d_1 = \frac{t_1}{3.6}(v - m + \frac{at_1}{2})$$

t_1 = time of initial maneuver in sec
a = average acceleration in km/h/sec
v = average speed of passing vehicles in km/h
m = difference in speeds of the two vehicles moving in the same direction and its average speed during the occupancy of the left lane is 5 to 10 mph (or 8 to 16 km/h) higher than of the overtaken vehicle

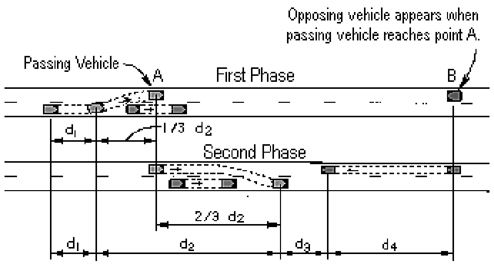
d_2 = distance traveled while the passing vehicle occupies left lane in meters

$$d_2 = \frac{vt_2}{3.6}$$

t_2 = time passing vehicle occupies the left lane usually found to be from 9.3 to 10.4 sec

d_3 = distance between the passing vehicle at the end of its maneuver and the opposing vehicle

d_4 = distance traversed by opposing vehicle for two-thirds of the time the passing vehicle occupies the left lane, or $2/3d_4$



o Total passing sight distance is given by:

$$s = d_1 + d_2 + d_3 + d_4$$

o Minimum passing sight distance is given by:

$$s = \frac{2}{3}d_2 + d_3 + d_4$$
$$= \frac{2}{3}d_2 + d_3 + \frac{2}{3}d_2$$
$$= \frac{4}{3}d_2 + d_3$$

Example 2: Compute the minimum passing sight distance for the following data.

Speed of the passing car = 90 km/h
Speed of the overtaken vehicle = 80 km/h
Time of initial maneuver = 4 sec.
Average acceleration = 2.4 km/h/sec.
Time passing vehicle occupies the left lane = 9 sec.
Distance between the passing vehicle at the end of its maneuver and the opposing vehicle = 80 m.

Solution: Minimum passing sight distance is

$$s = \frac{4}{3}d_2 + d_3$$

$$d_2 = \frac{vt_2}{3.6} = \frac{(90)(9)}{3.6} = 225\,m.$$

d_3 = distance between passing vehicle at the end of its maneuver and opposing vehicle
= 80 m.

Therefore, minimum passing distance = 4/3(225) + 80 = 380 m.

สมมติฐานประกอบการวิเคราะห์เรื่อง Sight distance:

- o PIEV time ประมาณ 2.5 sec. แบ่งเป็น Perception time 1 sec. และ Reaction time 1.5 sec.
- o ความสูงของสายตาคนขับ ประมาณ 3.75 ft. หรือ 1.15 m. และความสูงของวัตถุ ประมาณ 0.6 ins. หรือ 0.20 m. เป็นความสูงเฉลี่ยที่ใช้ในการวิเคราะห์
- o สภาพของผิวถนนเปียก และยางรถไม่ดี
- o สภาพอากาศดี และมีแสงสว่างเพียงพอ

Intermediate Sight Distance:

ระยะมองเห็นที่จัดไว้เพื่อให้รถสองคันที่ขับด้วยความเร็วเดียวกันสามารถหยุดได้ทันก่อนที่จะชนกัน โดยสมมติให้ความสูงของสายตาคนขับทั้งสองคันเท่ากับ 1.15 m. ระยะทางนี้จะมีค่าเป็น 2 เท่าของ Stopping sight distance

o เพื่อความสะดวกจึงมีการจัดทำตารางค่าต่ำสุดของระยะมองเห็นที่แซงได้โดยปลอดภัยบนถนนสองช่องจราจรในหน่วยเมตร

ความเร็วที่ใช้ออกแบบ (km/h)	50	60	70	80
ความเร็วสมมติ (km/h)				
- ยวดยานคันที่ถูกแซง	43	51	60	66
- ยวดยานคันที่แซง	59	67	76	82
การแล่นผ่านช่วงแรก				
a (km/h/sec)	2.24	2.24	2.29	2.32
t1 (sec)	3.6	3.8	4.0	4.1
d1 (m)	47	58	72	81
การครอบครองช่องจราจรทิศตรงข้าม				
t2 (sec)	9.3	9.6	10.0	10.3
d2 (m)	153	179	211	235
d3 (m)	31	38	55	76
d4 (m)	102	119	141	131
รวมระยะทางทั้งหมด (m)	333	394	479	550