



دانشگاه صنعتی اصفهان
دانشکده مهندسی حمل و نقل

طرح هندسی پیشرفته

فصل سوم: المان های طراحی
قوس افقی، تعریض

مدرس: محمد تمنایی

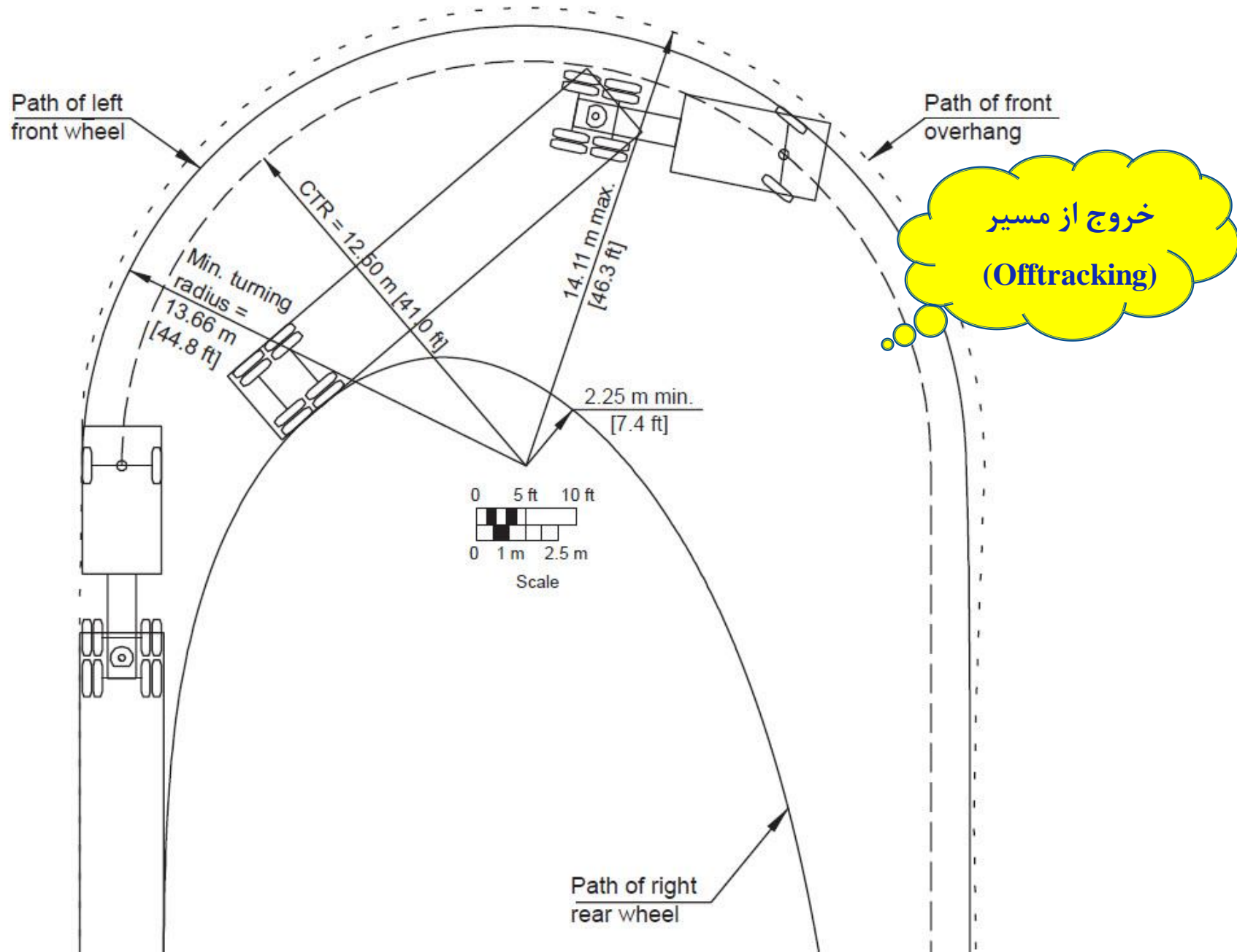
پاییز ۱۳۹۵



Filmaciones Chambe Telf: 553 3246 Lima - Perú

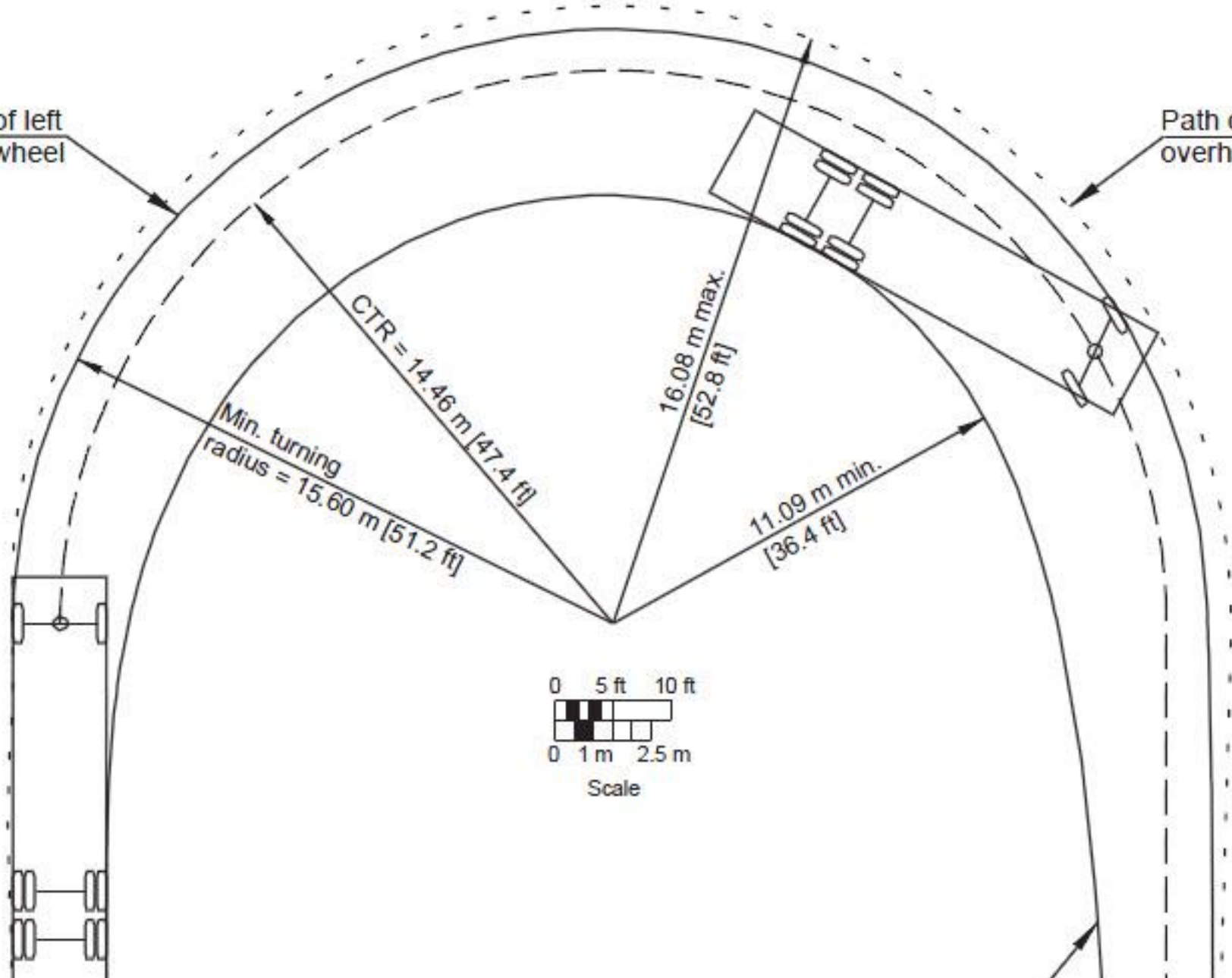
- ✓ تعریض در قوس افقی، چرا؟
- ✓ تعریض، داخل قوس یا خارج قوس؟
- ✓ مقدار اضافه عرض؟





Path of left front wheel

Path of front overhang



✓ حداکثر تعریض در قوس به چه چیز بستگی دارد؟



$$U = u + R - \sqrt{R^2 - \sum L_i^2}$$

where:

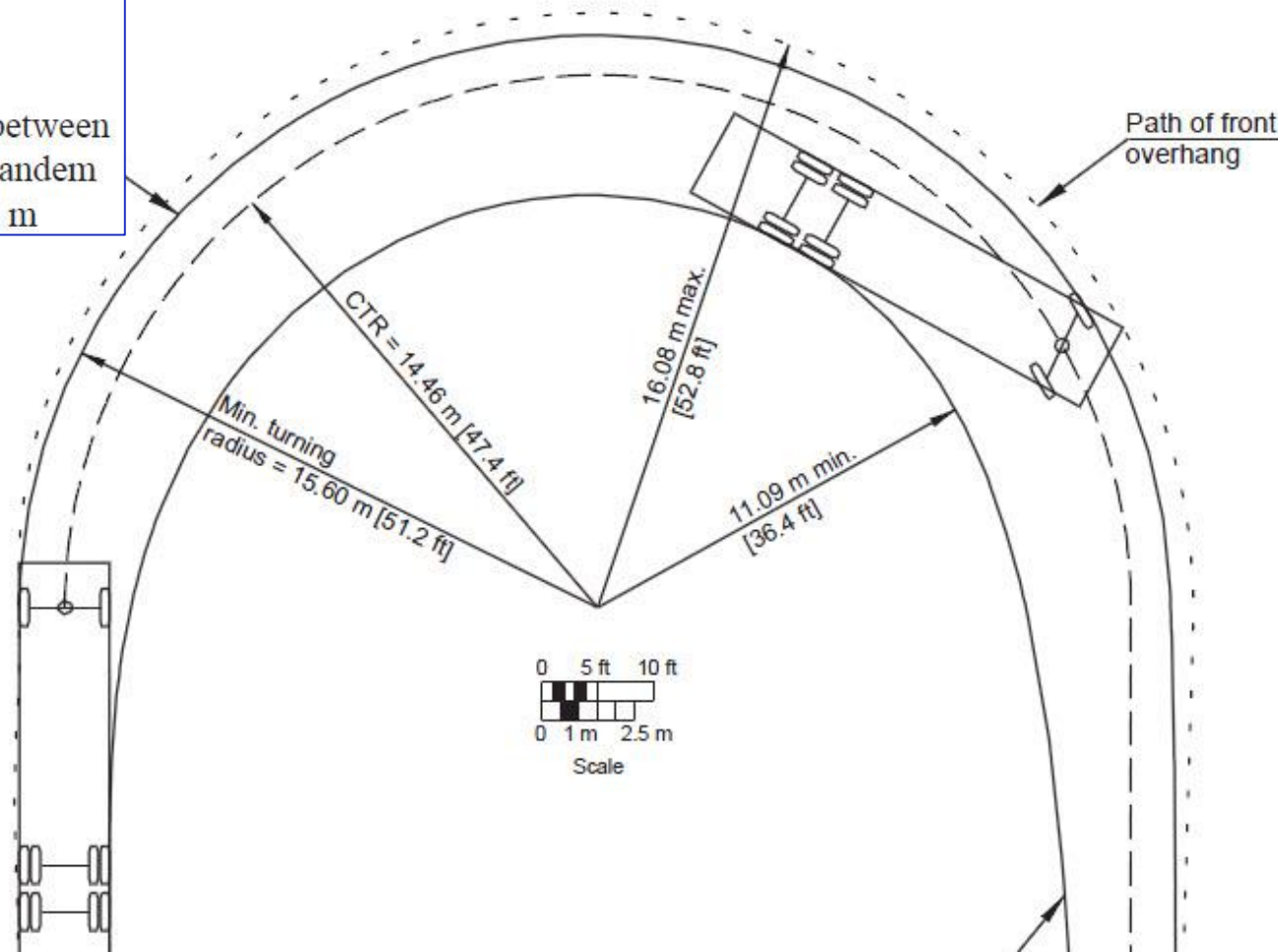
U = track width on curve, m

u = track width on tangent (out-to-out of tires), m

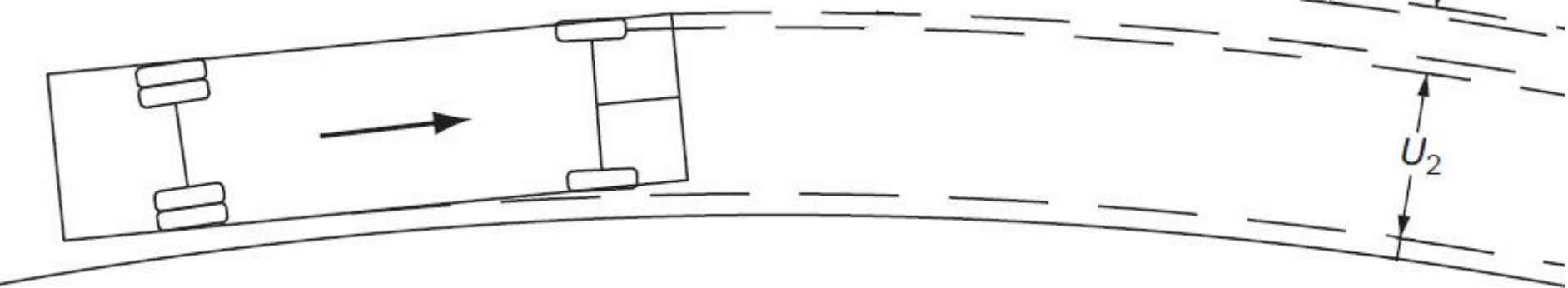
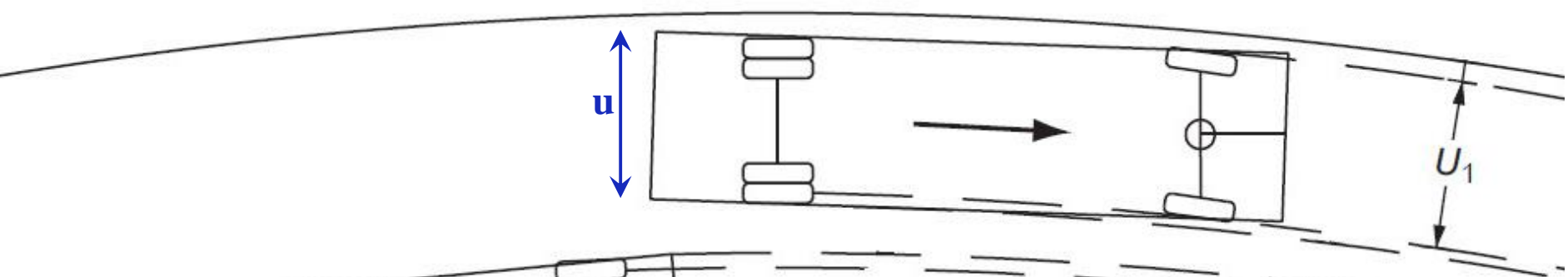
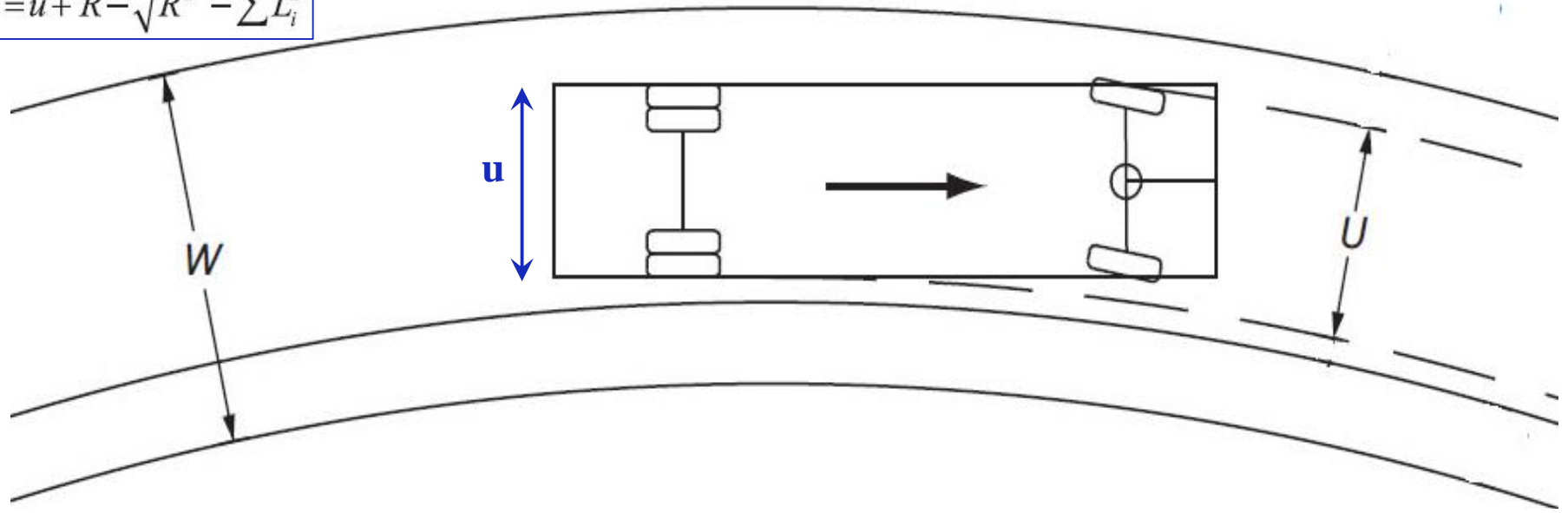
R = radius of curve or turn, m

L_i = wheelbase of design vehicle between consecutive axles (or sets of tandem axles) and articulation points, m

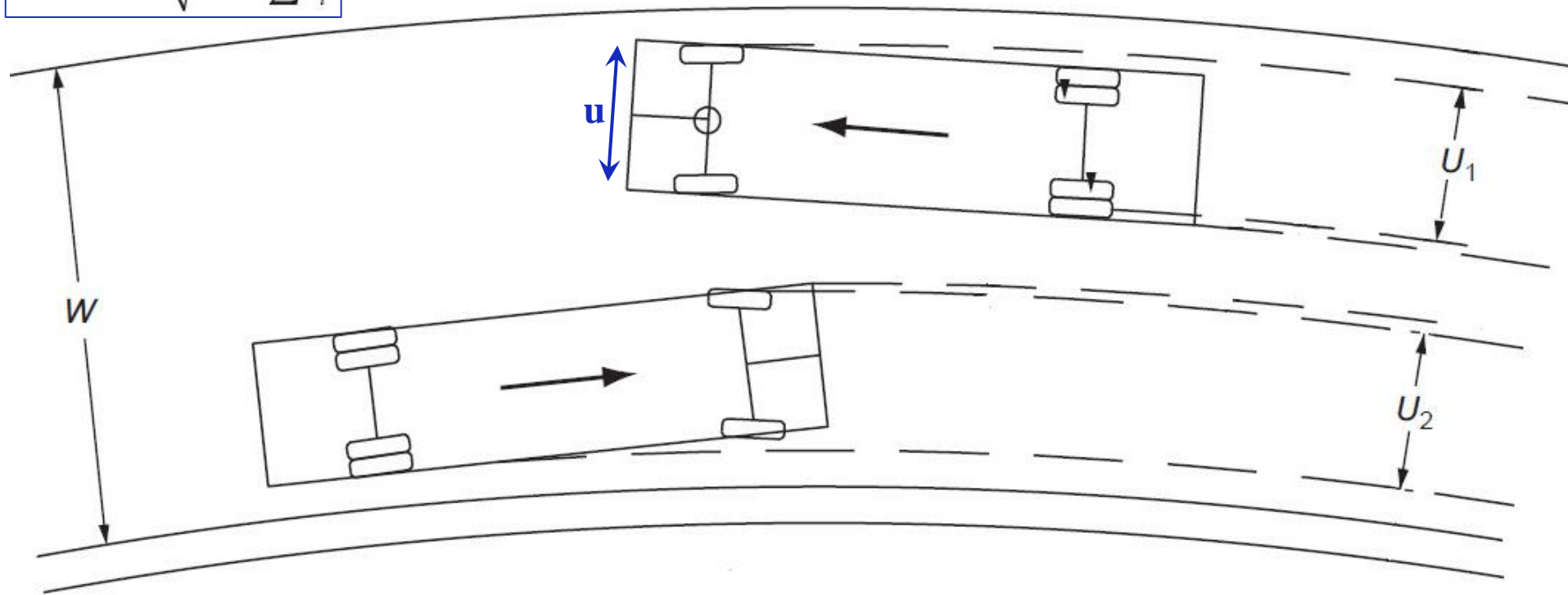
AASHTO
Eq. 3.31



$$U = u + R - \sqrt{R^2 - \sum L_i^2}$$

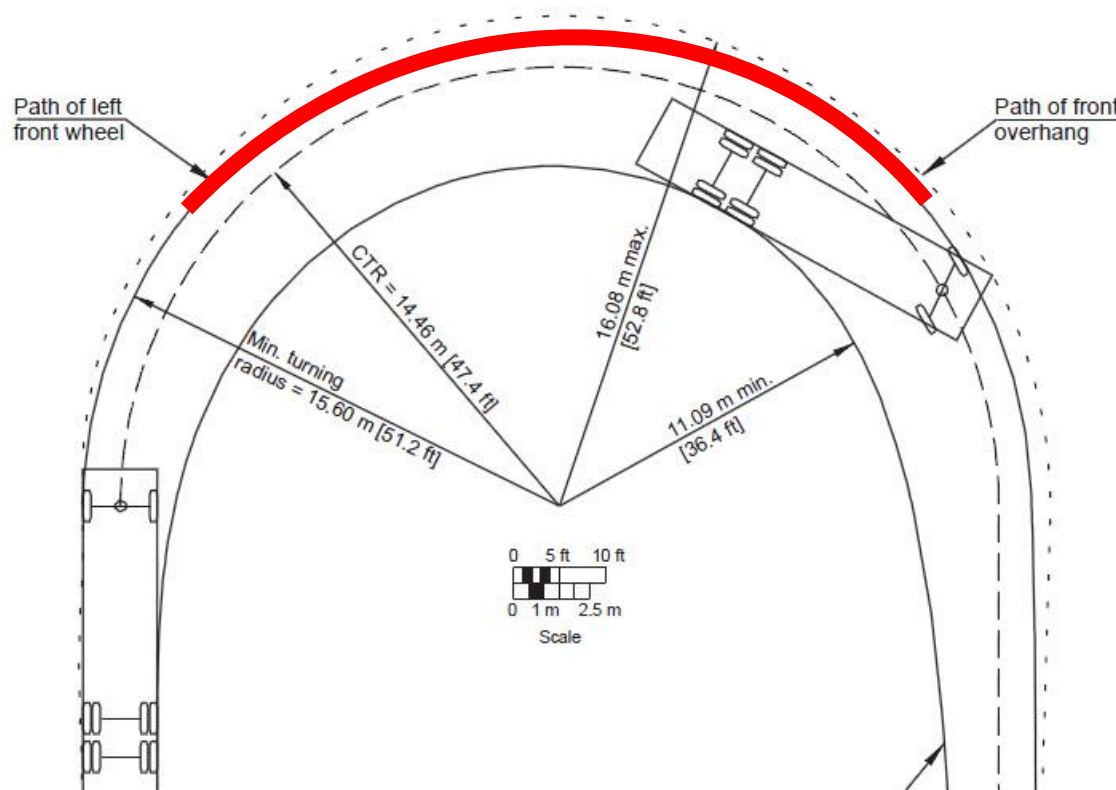


$$U = u + R - \sqrt{R^2 - \sum L_i^2}$$



R کدام شعاع؟

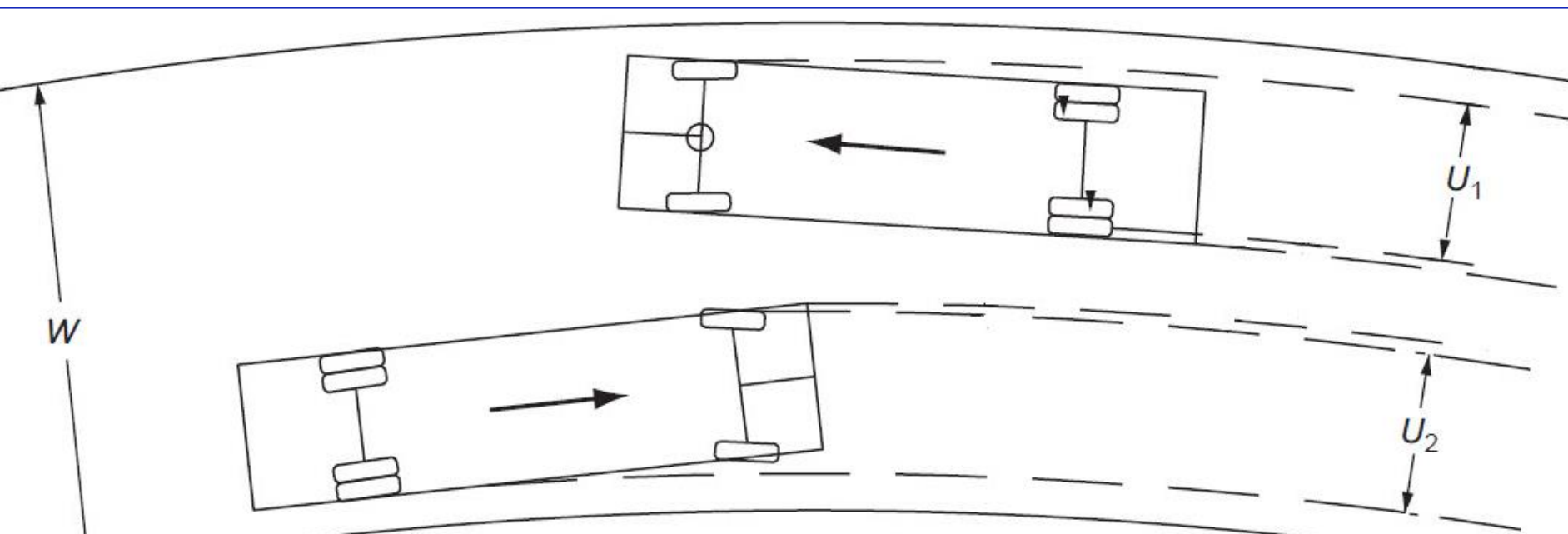
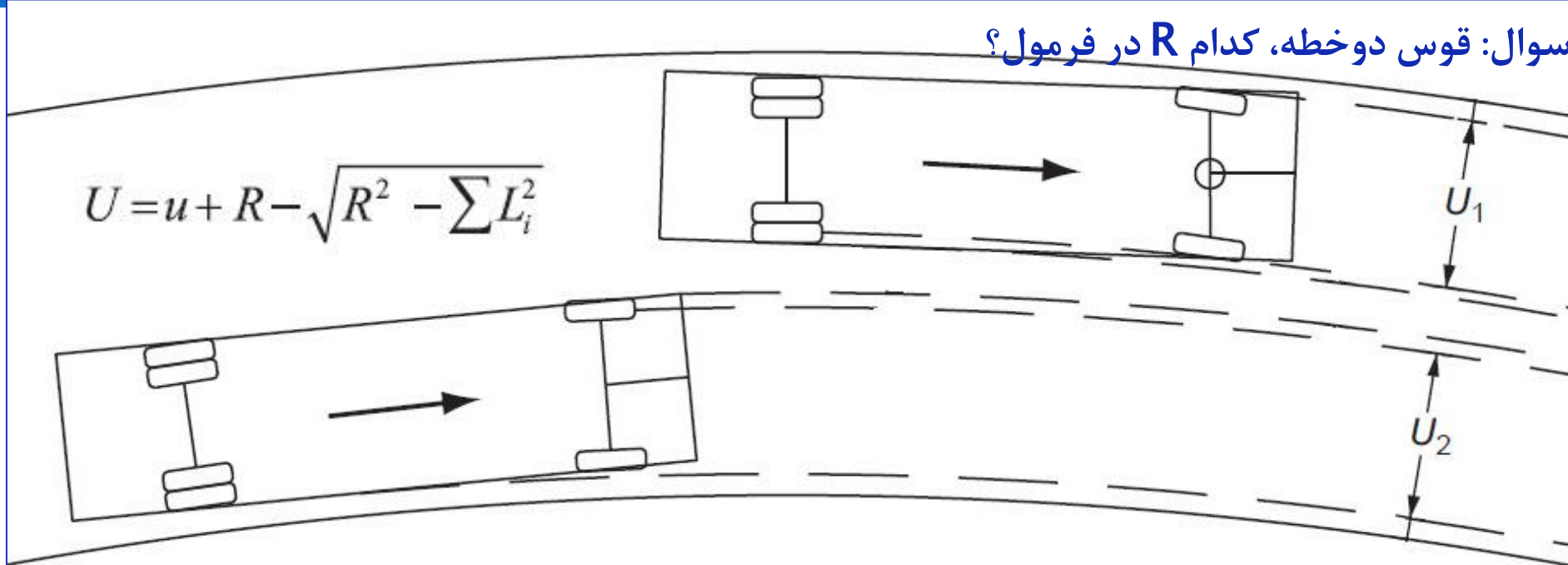
$$U = u + R - \sqrt{R^2 - \sum L_i^2}$$

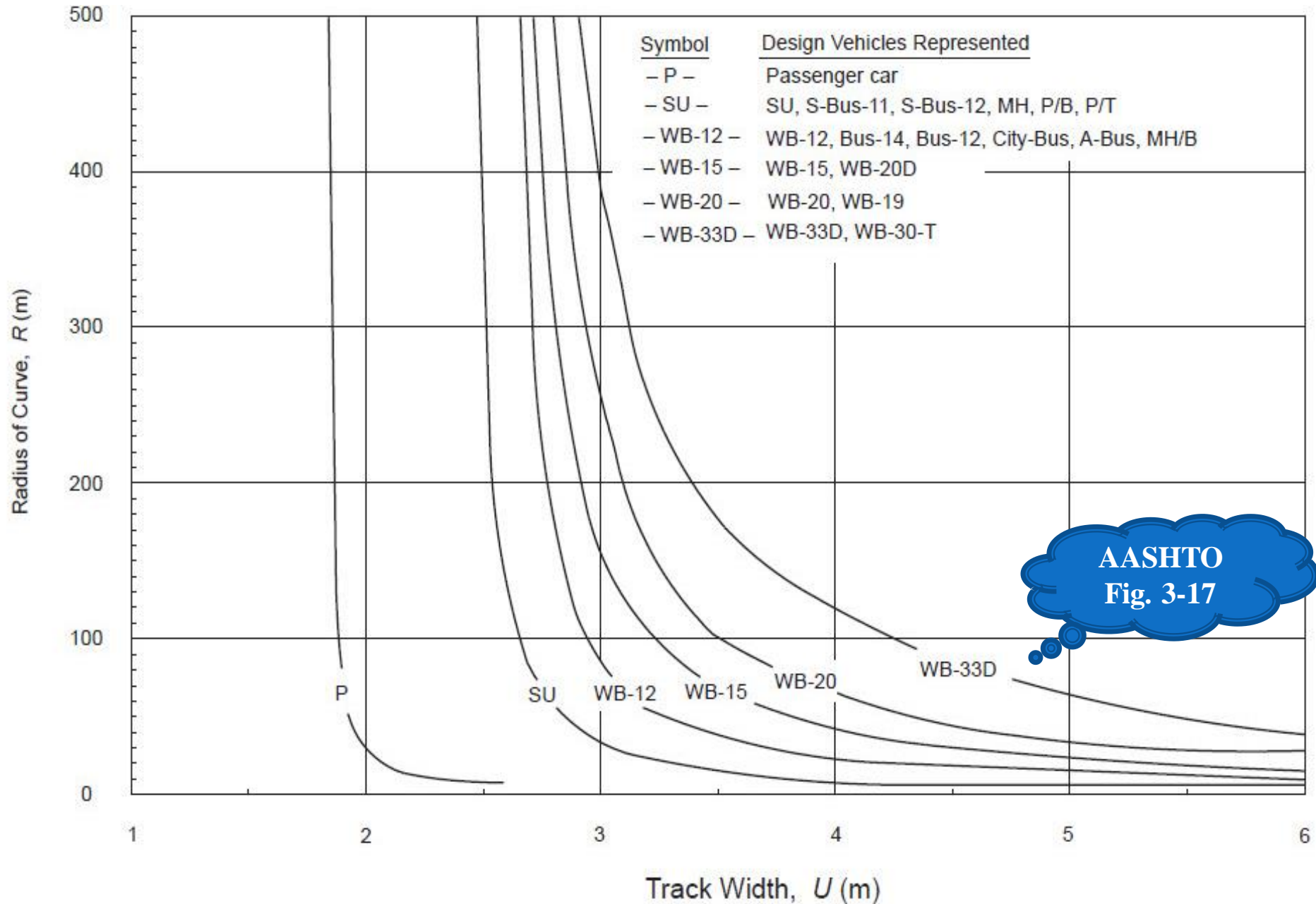


طرح هندسی

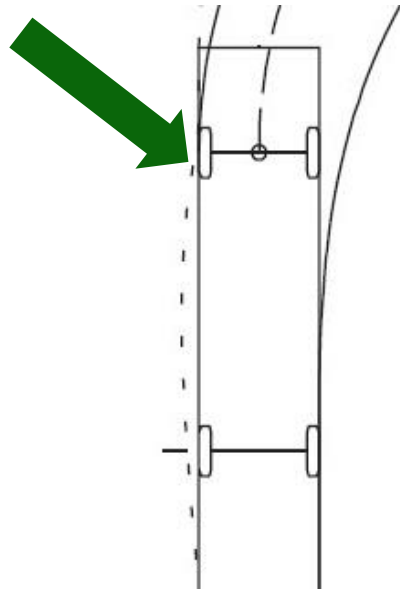
سوال: قوس دوخطه، کدام R در فرمول؟

$$U = u + R - \sqrt{R^2 - \sum L_i^2}$$

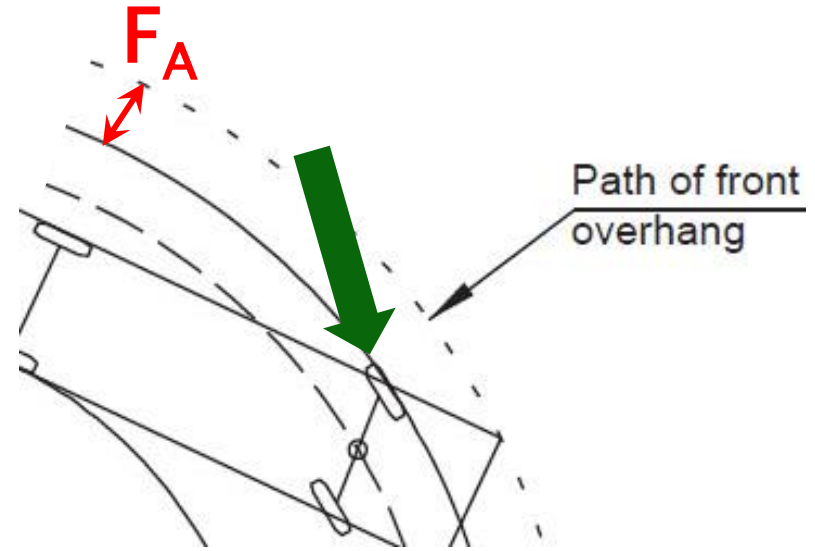




پهنای پیش آمدگی جلو (Front Overhang)



راستا در مسیر مستقیم



راستا در قوس



$$F_A = \sqrt{R^2 + A(2L + A)} - R$$

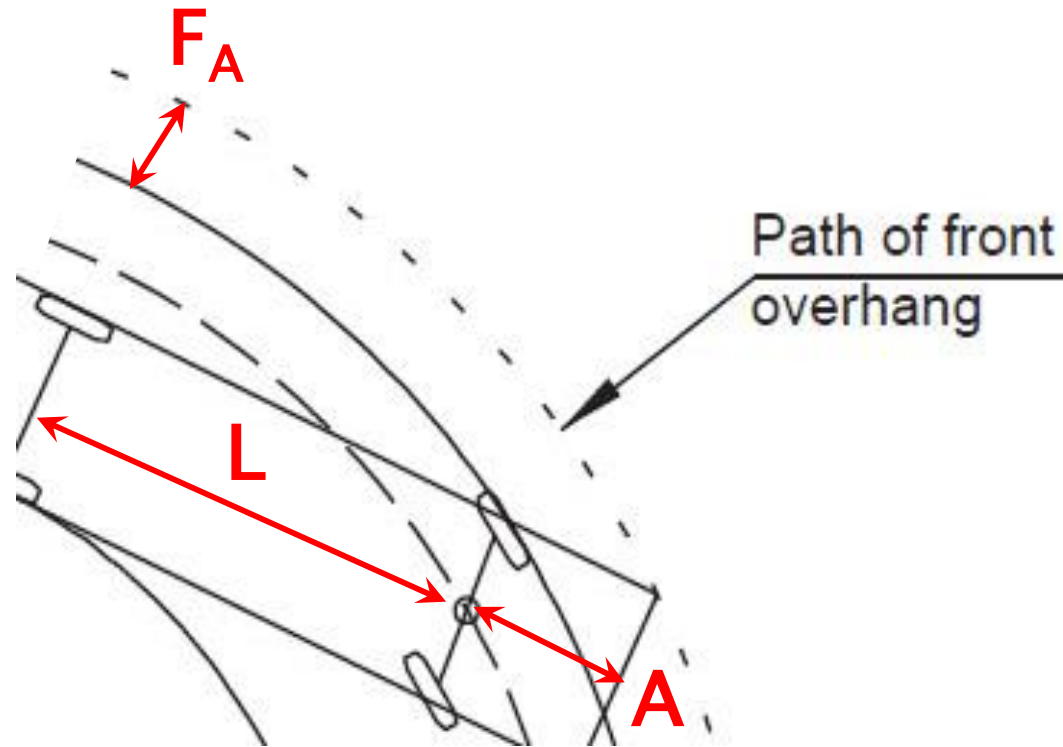
where:

F_A = width of front overhang, m

R = radius of curve or turning roadway
(two-lane), m

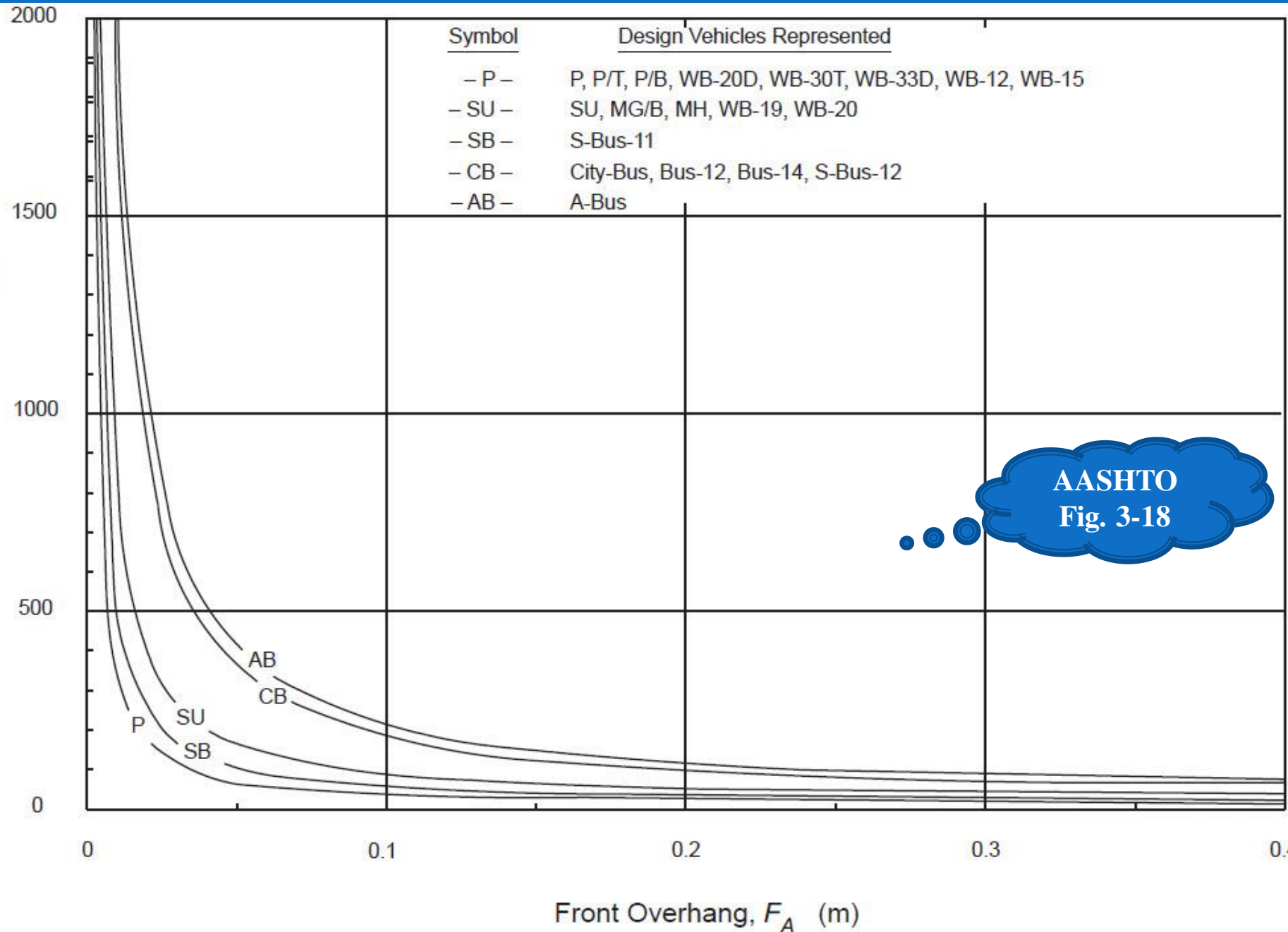
A = front overhang of inner lane vehicle,
m

L = wheelbase of single unit or
tractor, m



AASHTO
Eq. 3.32





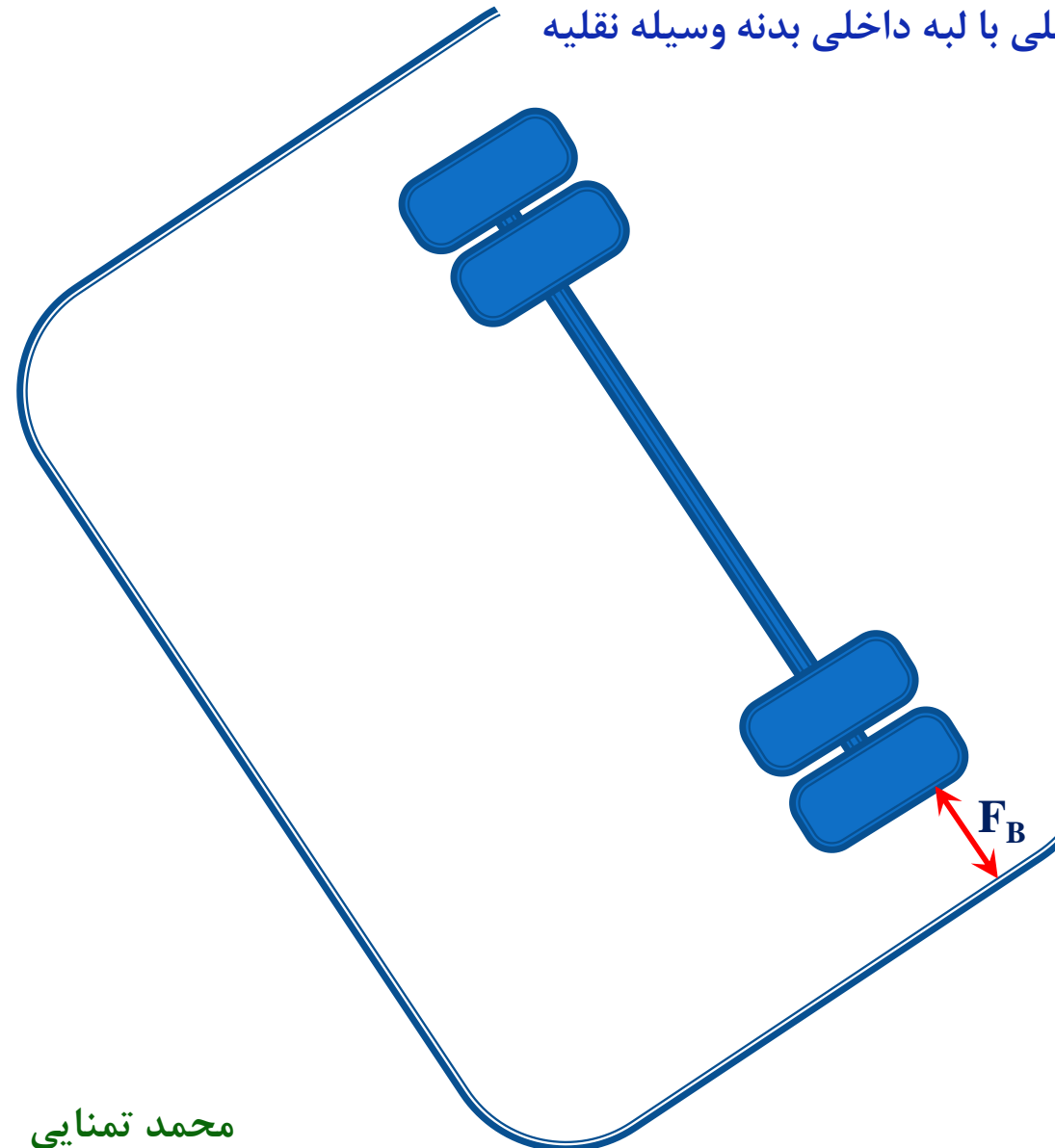
(C) Lateral Clearance Allowance فاصله آزاد جانبی وسیله نقلیه در قوس

عرض مسیر مستقیم دوخطه (W_n)	فاصله آزاد جانبی موردنیاز در قوس (C)
۶ متر	۰.۶ متر
۶.۶ متر	۰.۷۵ متر
۷.۲ متر	۰.۹ متر



عرض پیش آمدگی عقب در قوس (F_B)

فاصله شعاعی بین لبه بیرونی مسیر چرخ عقب داخلی با لبه داخلی بدنه وسیله نقلیه



عرض آزاد فوق العاده در قوس "extra width allowance" (Z)

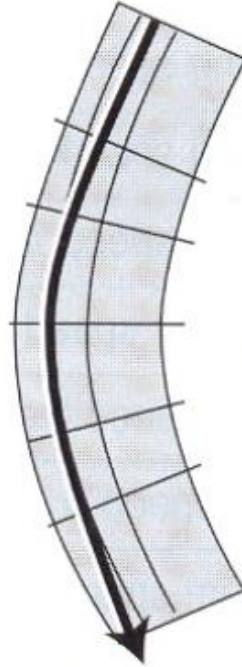
CUTTING



SWINGING



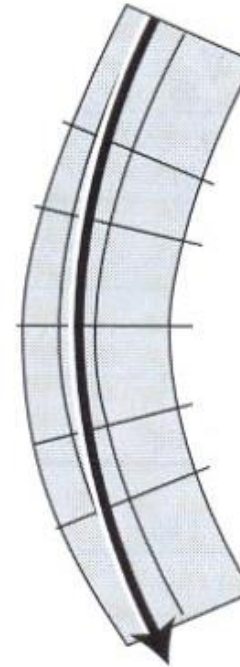
DRIFTING



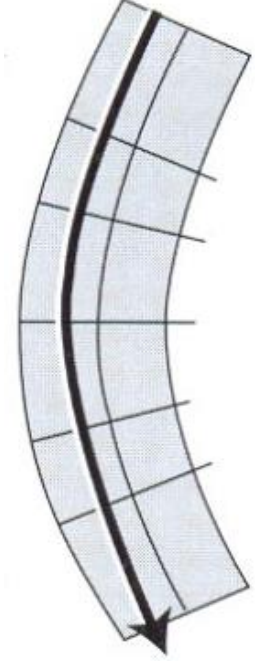
CORRECTING



NORMAL BEHAVIOR



IDEAL BEHAVIOR



(Z) "extra width allowance" عرض آزاد فوق العاده در قوس

$$Z = 0.1(V/\sqrt{R})$$

where:

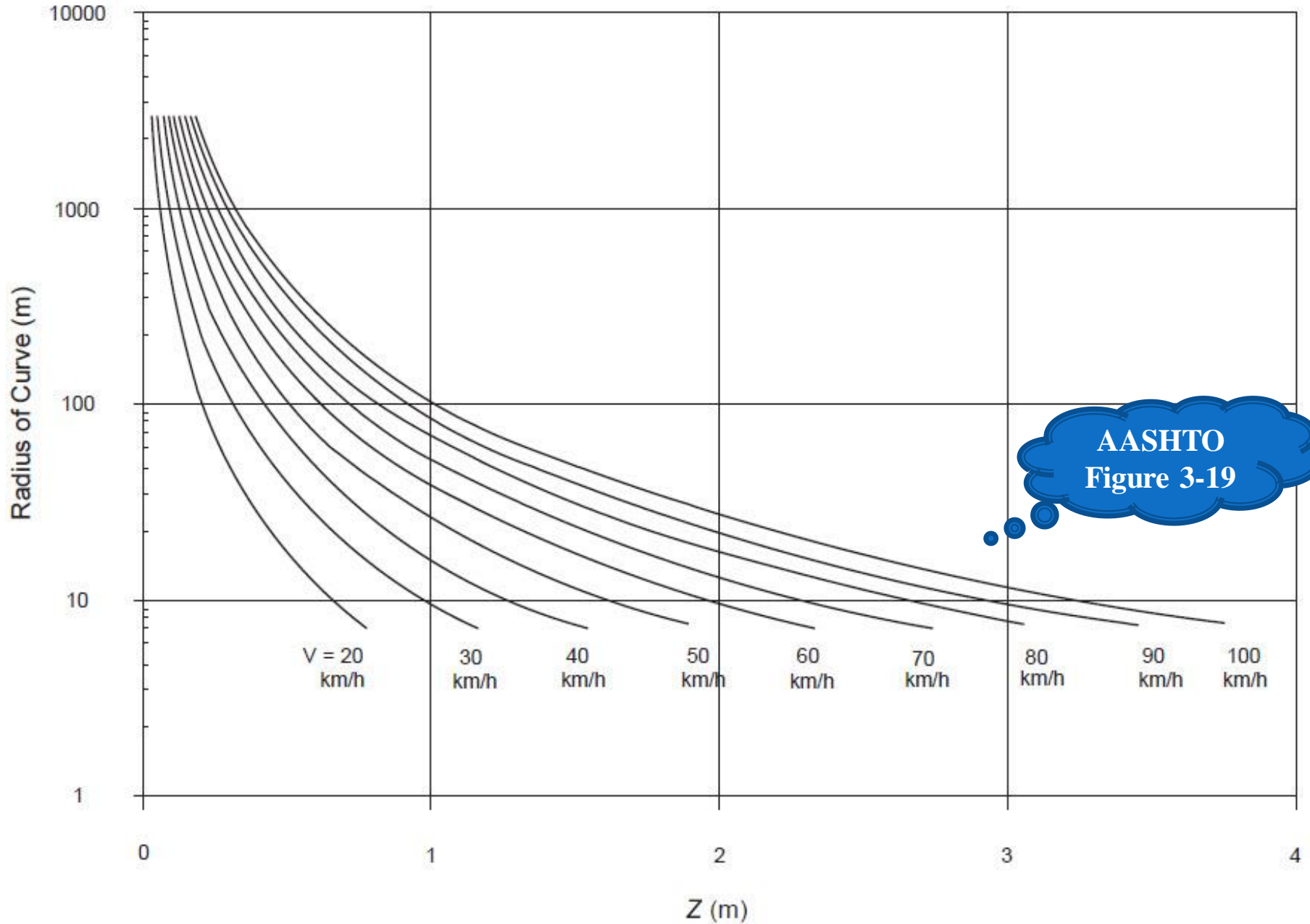
Z = extra width allowance, m

V = design speed of the highway, km/h

R = radius of curve or turning roadway
(two-lane), m

AASHTO
Eq. 3.33





تعریض در قوس

عرض مسیر U

+

عرض پیش آمدگی جلو F_A

+

عرض پیش آمدگی عقب F_B

+

عرض آزاد جانبی C

+

عرض آزاد فوق العاده Z



$$w = W_c - W_n$$

where:

w = widening of traveled way on curve, m

W_c = width of traveled way on curve, m

W_n = width of traveled way on tangent, m

$$W_c = N(U + C) + (N - 1)F_A + Z$$

where:

W_c = width of traveled way on curve, m

N = number of lanes

U = track width of design vehicle (out-to-out tires) on curves, m

C = lateral clearance, m

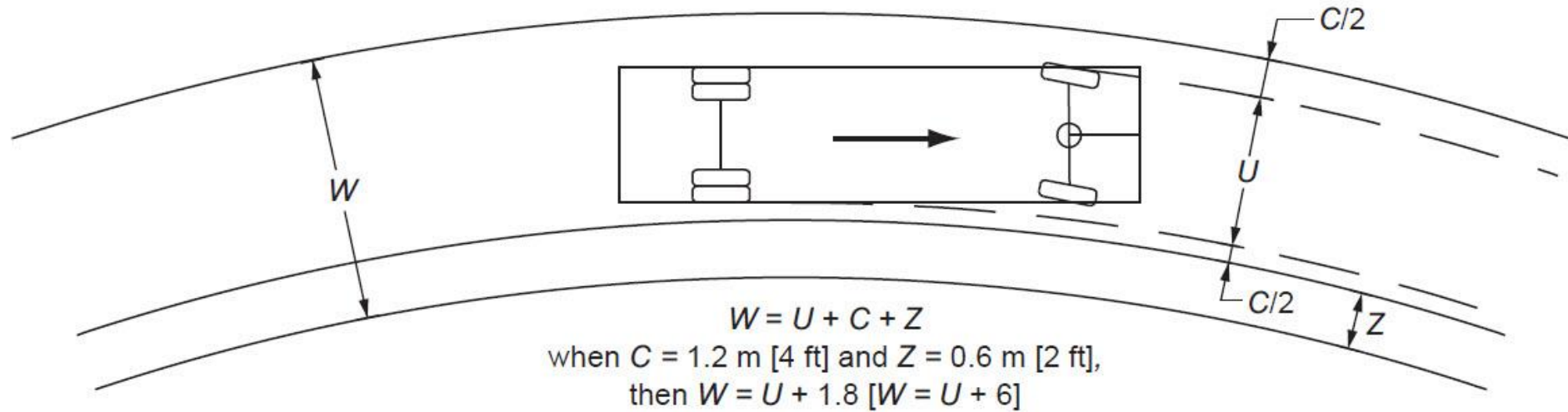
F_A = width of front overhang of inner-lane vehicle, m

Z = extra width allowance, m

AASHTO
Eq. 3.35



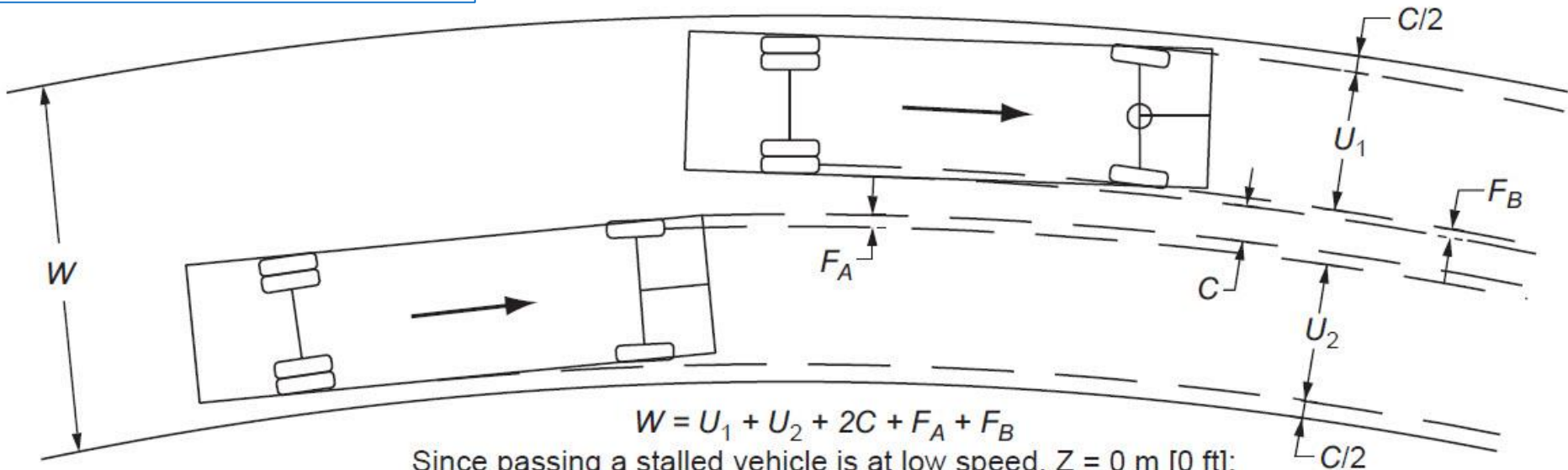
$$W_c = N(U + C) + (N - 1)F_A + Z$$



CASE I
 One-Lane One-Way Operation — No Passing



$$W_c = N(U + C) + (N - 1)F_A + Z$$



$$W = U_1 + U_2 + 2C + F_A + F_B$$

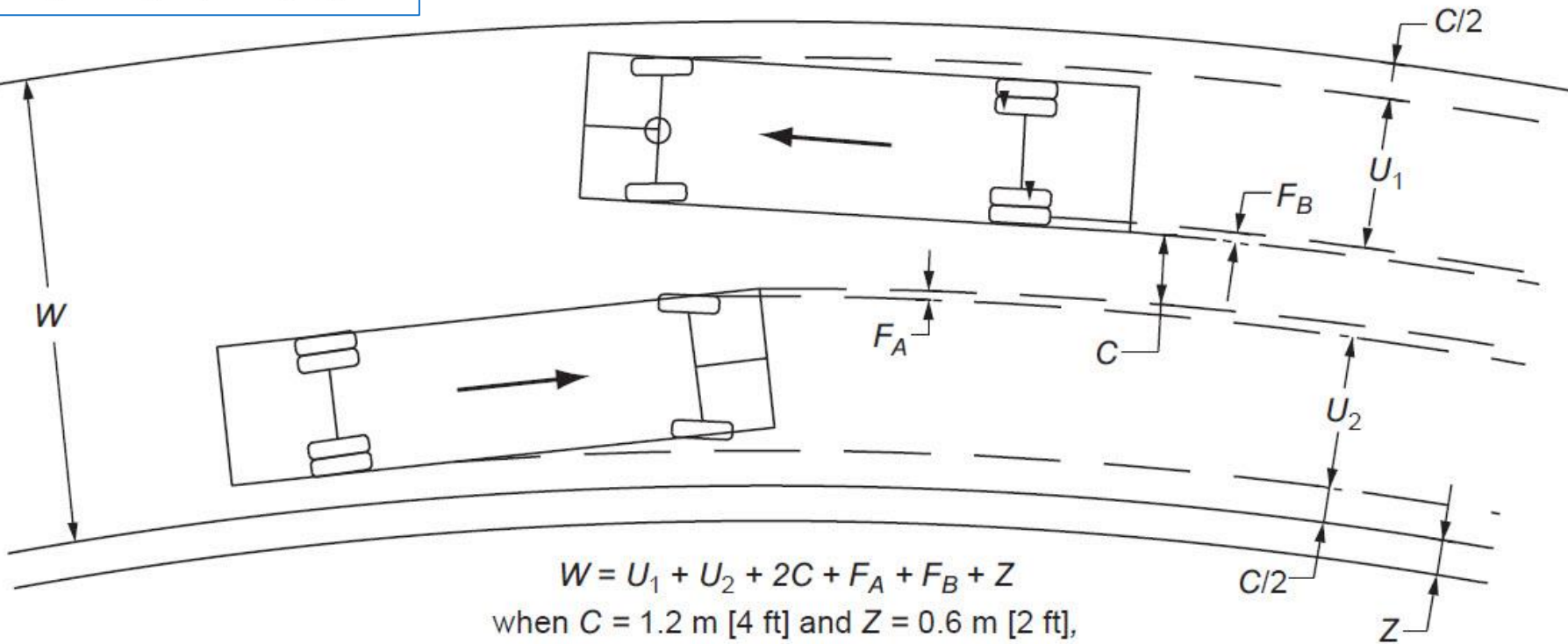
Since passing a stalled vehicle is at low speed, $Z = 0$ m [0 ft];
 then C is assumed half that for Cases I and III or $C = 0.6$ m [2 ft],
 then $W = U_1 + U_2 + F_A + F_B + 1.2$ [$W = U_1 + U_2 + F_A + F_B + 4$]

CASE II

One-Lane One-Way Operation Provision for Passing Stalled Vehicle



$$W_c = N(U + C) + (N - 1)F_A + Z$$



$$W = U_1 + U_2 + 2C + F_A + F_B + Z$$

when $C = 1.2 \text{ m [4 ft]}$ and $Z = 0.6 \text{ m [2 ft]}$,
 then $W = U_1 + U_2 + F_A + F_B + 3$ [$W = U_1 + U_2 + F_A + F_B + 10$]

CASE III
 Two-Lane Operation — One or Two Way



شرایط ترافیکی در محاسبه تعریض در قوس

A

B

C

Case	Metric		
	Design Traffic Condition		
	A	B	C
I	P	SU-9	WB-12
II	P-P	P-SU-9	SU-9-SU-9
III	P-SU-9	SU-9-SU-9	WB-12-WB-12

AASHTO
Page 3.103



طرح هندسی

عرض خط برای انواع وسایل نقلیه در حالات ۱ و ۲ و ۳

Table 3-28a. Derived Pavement Widths for Turning Roadways for Different Design Vehicles

Metric																				
Radius on Inner Edge of Pavement, R (m)	Case I, One-Lane Operation, No Provision for Passing a Stalled Vehicle																			
	P	SU-9	SU-12	BUS-12	BUS-14	CITY-BUS	S-BUS-11	S-BUS-12	A-BUS-11	WB-12	WB-19	WB-20	WB-20D	WB-28D	WB-30T	WB-33D	MH	P/T	P/B	MH/B
15	4.0	5.5	6.3	6.6	7.2	6.5	5.7	5.5	6.7	7.0	13.5	—	8.8	—	11.6	—	5.5	5.7	5.4	6.5
25	3.9	5.0	5.4	5.7	5.9	5.6	5.1	5.0	5.7	5.8	8.5	9.5	6.8	9.6	7.9	12.0	5.0	5.1	4.9	5.5
30	3.8	4.9	5.2	5.4	5.7	5.4	5.0	4.9	5.5	5.5	7.8	8.5	6.3	8.6	7.3	10.3	4.9	5.0	4.8	5.3
50	3.7	4.6	4.8	5.0	5.2	5.0	4.7	4.6	5.0	5.0	6.3	6.7	5.5	6.8	6.1	7.7	4.6	4.7	4.6	4.9
75	3.7	4.5	4.6	4.8	4.9	4.8	4.5	4.5	4.8	4.7	5.7	5.9	5.1	6.0	5.5	6.6	4.5	4.5	4.5	4.7
100	3.7	4.4	4.5	4.7	4.8	4.7	4.5	4.4	4.7	4.6	5.3	5.5	5.0	5.6	5.2	6.0	4.4	4.5	4.4	4.5
125	3.7	4.4	4.5	4.6	4.7	4.6	4.4	4.4	4.6	4.5	5.2	5.3	4.8	5.3	5.0	5.7	4.4	4.4	4.4	4.5
150	3.7	4.4	4.4	4.6	4.6	4.6	4.4	4.4	4.6	4.5	5.0	5.2	4.8	5.2	4.9	5.5	4.4	4.4	4.4	4.4
Tangent	3.6	4.2	4.2	4.4	4.4	4.4	4.2	4.2	4.4	4.2	4.4	4.4	4.4	4.4	4.4	4.4	4.2	4.2	4.2	4.2
Case II, One-Lane, One-Way Operation with Provision for Passing a Stalled Vehicle by Another of the Same Type																				
15	6.0	9.2	10.9	11.9	13.1	11.7	9.4	9.7	12.4	11.8	25.2	—	15.4	—	20.9	—	9.2	9.3	8.7	11.0
25	5.6	7.9	8.9	9.6	10.2	9.5	8.0	8.2	9.9	9.3	15.0	16.8	11.2	16.9	13.5	21.7	7.9	7.9	7.6	8.9
30	5.5	7.6	8.4	9.0	9.5	9.0	7.7	7.8	9.3	8.8	13.4	14.8	10.4	14.9	12.2	18.4	7.6	7.6	7.4	8.4
50	5.3	7.0	7.5	8.0	8.3	7.9	7.0	7.1	8.1	7.7	10.4	11.2	8.7	11.2	9.8	13.1	7.0	7.0	6.8	7.5
75	5.2	6.7	7.0	7.4	7.6	7.4	6.7	6.8	7.5	7.1	9.1	9.6	7.9	9.6	8.6	10.8	6.7	6.7	6.6	7.0
100	5.2	6.5	6.8	7.2	7.3	7.1	6.6	6.6	7.2	6.9	8.4	8.8	7.5	8.8	8.1	9.7	6.5	6.5	6.5	6.8

Table 3-28a. Derived Pavement Widths for Turning Roadways for Different Design Vehicles

Metric																					
Radius on Inner Edge of Pavement, R (m)	Case I, One-Lane Operation, No Provision for Passing a Stalled Vehicle																				
	P	SU-9	SU-12	BUS-12	BUS-14	CITY-BUS	S-BUS-11	S-BUS-12	A-BUS-11	WB-12	WB-19	WB-20	WB-20D	WB-28D	WB-30T	WB-33D	MH	P/T	P/B	B	MH/B
15	4.0	5.5	6.3	6.6	7.2	6.5	5.7	5.5	6.7	7.0	13.5	—	8.8	—	11.6	—	5.5	5.7	5.4	6.5	
25	3.9	5.0	5.4	5.7	5.9	5.6	5.1	5.0	5.7	5.8	8.5	9.5	6.8	9.6	7.9	12.0	5.0	5.1	4.9	5.5	
30	3.8	4.9	5.2	5.4	5.7	5.4	5.0	4.9	5.5	5.5	7.8	8.5	6.3	8.6	7.3	10.3	4.9	5.0	4.8	5.3	
50	3.7	4.6	4.8	5.0	5.2	5.0	4.7	4.6	5.0	5.0	6.3	6.7	5.5	6.8	6.1	7.7	4.6	4.7	4.6	4.9	
75	3.7	4.5	4.6	4.8	4.9	4.8	4.5	4.5	4.8	4.7	5.7	5.9	5.1	6.0	5.5	6.6	4.5	4.5	4.5	4.7	
100	3.7	4.4	4.5	4.7	4.8	4.7	4.5	4.4	4.7	4.6	5.3	5.5	5.0	5.6	5.2	6.0	4.4	4.5	4.4	4.5	
125	3.7	4.4	4.5	4.6	4.7	4.6	4.4	4.4	4.6	4.5	5.2	5.3	4.8	5.3	5.0	5.7	4.4	4.4	4.4	4.5	
150	3.7	4.4	4.4	4.6	4.6	4.6	4.4	4.4	4.6	4.5	5.0	5.2	4.8	5.2	4.9	5.5	4.4	4.4	4.4	4.4	
Tangent	3.6	4.2	4.2	4.4	4.4	4.4	4.2	4.2	4.4	4.2	4.4	4.4	4.4	4.4	4.4	4.4	4.2	4.2	4.2	4.2	
Case II, One-Lane, One-Way Operation with Provision for Passing a Stalled Vehicle by Another of the Same Type																					
15	6.0	9.2	10.9	11.9	13.1	11.7	9.4	9.7	12.4	11.8	25.2	—	15.4	—	20.9	—	9.2	9.3	8.7	11.0	
25	5.6	7.9	8.9	9.6	10.2	9.5	8.0	8.2	9.9	9.3	15.0	16.8	11.2	16.9	13.5	21.7	7.9	7.9	7.6	8.9	
30	5.5	7.6	8.4	9.0	9.5	9.0	7.7	7.8	9.3	8.8	13.4	14.8	10.4	14.9	12.2	18.4	7.6	7.6	7.4	8.4	
50	5.3	7.0	7.5	8.0	8.3	7.9	7.0	7.1	8.1	7.7	10.4	11.2	8.7	11.2	9.8	13.1	7.0	7.0	6.8	7.5	
75	5.2	6.7	7.0	7.4	7.6	7.4	6.7	6.8	7.5	7.1	9.1	9.6	7.9	9.6	8.6	10.8	6.7	6.7	6.6	7.0	
100	5.2	6.5	6.8	7.2	7.3	7.1	6.6	6.6	7.2	6.9	8.4	8.8	7.5	8.8	8.1	9.7	6.5	6.5	6.5	6.8	



Metric			
Case	Design Traffic Condition		
	A	B	C
I	P	SU-9	WB-12
II	P-P	P-SU-9	SU-9-SU-9
III	P-SU-9	SU-9-SU-9	WB-12-WB-12

Table 3-29. Design Widths of Pavements for Turning R

Metric									
Radius on Inner Edge of Pavement, R (m)	Pavement Width (m)								
	Case I One-Lane, One-Way Operation—no provision for passing stalled vehicle			Case II One-Lane, One-Way Operation—with provision for passing stalled vehicle			Case III Two-Lane Operation—either one-way or two-way operation		
	Design Traffic Conditions								
	A	B	C	A	B	C	A	B	C
15	5.4	5.5	7.0	6.0	7.8	9.2	9.4	11.0	13.6
25	4.8	5.0	5.8	5.6	6.9	7.9	8.6	9.7	11.1
30	4.5	4.9	5.5	5.5	6.7	7.6	8.4	9.4	10.6
50	4.2	4.6	5.0	5.3	6.3	7.0	7.9	8.8	9.5
75	3.9	4.5	4.8	5.2	6.1	6.7	7.7	8.5	8.9
100	3.9	4.5	4.8	5.2	5.9	6.5	7.6	8.3	8.7
125	3.9	4.5	4.8	5.1	5.9	6.4	7.6	8.2	8.5
150	3.6	4.5	4.5	5.1	5.8	6.4	7.5	8.2	8.4
Tangent	3.6	4.2	4.2	5.0	5.5	6.1	7.3	7.9	7.9

داده مسئله:

شعاع قوس

شرایط ترافیکی (A یا B یا C)

حالت (Case I یا Case II یا Case III)

خواسته مسئله:

میزان تعریض؟

خلاصه:

۱- تعیین R قوس

۲- محاسبه تعریض قوس با جدول 3-29



Table 3-29. Design Widths of Pavements for Turning R

Metric									
Radius on Inner Edge of Pavement, R (m)	Pavement Width (m)								
	Case I One-Lane, One-Way Operation—no provision for passing stalled vehicle			Case II One-Lane, One-Way Operation—with provision for passing stalled vehicle			Case III Two-Lane Operation—either one-way or two-way operation		
	Design Traffic Conditions								
	A	B	C	A	B	C	A	B	C
15	5.4	5.5	7.0	6.0	7.8	9.2	9.4	11.0	13.6
25	4.8	5.0	5.8	5.6	6.9	7.9	8.6	9.7	11.1
30	4.5	4.9	5.5	5.5	6.7	7.6	8.4	9.4	10.6
50	4.2	4.6	5.0	5.3	6.3	7.0	7.9	8.8	9.5
75	3.9	4.5	4.8	5.2	6.1	6.7	7.7	8.5	8.9
100	3.9	4.5	4.8	5.2	5.9	6.5	7.6	8.3	8.7
125	3.9	4.5	4.8	5.1	5.9	6.4	7.6	8.2	8.5
150	3.6	4.5	4.5	5.1	5.8	6.4	7.5	8.2	8.4
Tangent	3.6	4.2	4.2	5.0	5.5	6.1	7.3	7.9	7.9

میزان تعریض قوس درونشهری تک خطه برای کامیون در سرعت طراحی برای دوربرگردان (برابر ۲۵ کیلومتر بر ساعت)؟ (۲۰٪ ترافیک خودروی سنگین)

Table 3-29. Design Widths of Pavements for Turning R

Metric									
Radius on Inner Edge of Pavement, R (m)	Pavement Width (m)								
	Case I One-Lane, One-Way Operation—no provision for passing stalled vehicle			Case II One-Lane, One-Way Operation—with provision for passing stalled vehicle			Case III Two-Lane Operation—either one-way or two-way operation		
	Design Traffic Conditions								
	A	B	C	A	B	C	A	B	C
15	5.4	5.5	7.0	6.0	7.8	9.2	9.4	11.0	13.6
25	4.8	5.0	5.8	5.6	6.9	7.9	8.6	9.7	11.1
30	4.5	4.9	5.5	5.5	6.7	7.6	8.4	9.4	10.6
50	4.2	4.6	5.0	5.3	6.3	7.0	7.9	8.8	9.5
75	3.9	4.5	4.8	5.2	6.1	6.7	7.7	8.5	8.9
100	3.9	4.5	4.8	5.2	5.9	6.5	7.6	8.3	8.7
125	3.9	4.5	4.8	5.1	5.9	6.4	7.6	8.2	8.5
150	3.6	4.5	4.5	5.1	5.8	6.4	7.5	8.2	8.4
Tangent	3.6	4.2	4.2	5.0	5.5	6.1	7.3	7.9	7.9



در قوس ساده ممکن است یک دوم تا دو سوم طول تأمین اضافه عرض، در امتداد مستقیم و مابقی در طول قوس انجام شود. این روش مشابه روشی است که برای تأمین طول شیب بر بلندی به کار می رود. در قوس با اتصال تدریجی، تأمین اضافه عرض در طول قوس اتصال تدریجی انجام می شود.

آیین نامه ۴۱۵
صفحه ۶۵

