Table 5-6. Summary of Maximum Deflections

Run Number	Post Spacing		Beam Description	Impact Angle	Maximum Deflection[a]			
					Simulation		Field Test[b]	
	mm	[in.]			mm	[in.]	mm	[in.]
1	1905	[75]	Single W-Beam	15°	589	[23.2]	NA	NA
2	1905	[75]	Single W-Beam	25°	907	[35.7]	754	[29.7]
3	952	[38]	Single W-Beam	15°	389	[15.3]	NA	NA
4	952	[38]	Single W-Beam	25°	541	[21.3]	597	[23.5]
**	1905	[75]	MSG Single W-Beam	25°	NA	NA	1094	[43.1]
**	953	[38]	MSG Single W-Beam	25°	578[d]	[22.8][d]	NA	NA
**	476	[19]	MGS Single W-Beam	25°	NA	NA	447	[17.6]
*	1905	[75]	Double W-Beam	25°	NA	NA	902[c]	[35.5]
5	952	[38]	Double W-Beam	15°	358	[14.1]	NA	NA
6	952	[38]	Double W-Beam	25°	437	[17.2]	498	[19.6]
7	476	[19]	Double W-Beam	15°	NA	NA	NA	NA
8	476	[19]	Double W-Beam	25°	320	[12.3]	NA	NA
9	1905	[75]	Single Thrie-Beam	15°	488	[19.2]	NA	NA
10	1905	[75]	Single Thrie Beam	25°	716	[28.2]	NA	NA
11	952	[38]	Single Thrie-Beam	15°	386	[15.2]	NA	NA
12	952	[38]	Single Thrie-Beam	25°	480	[18.9]	NA	NA
13	952	[38]	Double Thrie-Beam	15°	333	[13.1]	NA	NA
14	952	[38]	Double Thrie Beam	25°	414	[16.3]	NA	NA
15	476	[19]	Single Thrie-Beam	15°	NA	NA	NA	NA
16	476	[19]	Single Thrie-Beam	25°	353	[13.9]	NA	NA
17	476	[19]	Double Thrie-Beam	15°	NA	NA	NA	NA
18	476	[19]	Double Thrie-Beam	25°	307	[12.1]	NA	NA

Notes:
a) Simulation of 2000-kg [4,400-lb] sedan at 97 km/h [60 mph].
b) Kansas Department of Transportation field test results with 2000-kg [4400-lb] sedan at 97 km/h [60mph].
c) Test conducted during wet soil conditions.
d) BARRIER VII Analysis results calibrated from crash tests of standard and $^1/_4$ post spacing.
NA = Not Available
*Field test only
** Crash Test of 2000P pickup truck at NCHRP Report 350 TL-3

The Zone of Intrusion (ZOI) is the region measured above and behind the face of a barrier system where an impacting vehicle or any major part of the system may extend during an impact. Figures 5-27 through 5-31 provide preliminary guidelines for the ZOI for various barrier types and test levels. These guidelines are based on review of crash test data and estimation of the ZOI parameters *(11, 23)*. More full-scale crash testing is needed to address the ZOI for rigid objects, such as bridge columns placed behind barriers of different heights and profiles. The amount of intrusion behind the barrier is related to the barrier height and profile as well as the vehicle size, speed, and angle of impact. For TL-4 and higher applications, and where practical, the designer should try to accommodate this additional distance behind the barrier as part of new or reconstruction projects. Narrowing of the roadway is not preferred on high-speed facilities to accommodate additional clearance for ZOI. For example, at an existing overpass structure where the pavement underneath is being reconstructed, it is usually not recommended to reduce shoulder width in order to gain additional clearance behind the barrier per these ZOI guidelines.

Deflection*	
Field Test*	
	[in.]
	NA
	[29.7]
	NA
	[23.5]
	[43.1]
	NA
	[17.6]
	[35.5]
	NA
	[19.6]
	NA
	NA
	NA
	NA
	NA
	NA
	NA
	NA
	NA

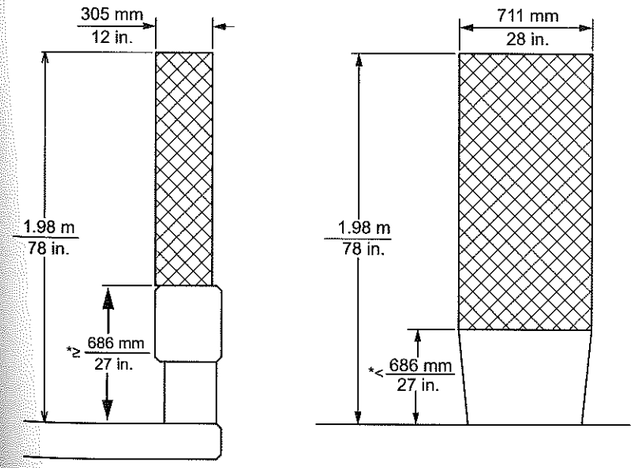
g vehicle or any
the ZOI for vari-
meters *(11, 23)*.
ers of different
the vehicle size,
modate this ad-
on high-speed
ent underneath
ind the barrier

When placing the bridge pier beyond the clear zone is impractical at overpass structures, a longitudinal roadside barrier is typically provided to shield an errant vehicle and its occupants from a collision with the bridge pier. From a roadside safety perspective, a TL-3 barrier is typically sufficient to shield the motorists from a pier located within the clear zone. However, structural issues with the bridge may call for the need for a higher test level barrier, not based on roadside safety criterion. The *AASHTO LRFD Bridge Design Specifications (14)* specify that bridge piers that are within 9 m [30 ft.] of the traveled way should be designed to withstand a large impact load or be shielded with a specified barrier system. The following height guidelines from the *AASHTO LRFD Bridge Design Specifications* are based on offset from the traveled way to the face of the pier:

- A 1370-mm [54-in.] high barrier located 3 m [10 ft] or less from the pier, or
- A 1070-mm [42-in.] high barrier located more than 3 m [10 ft.] from the pier.

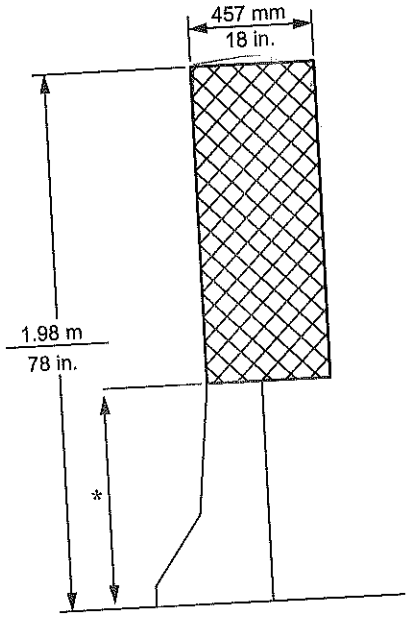
Typically a barrier would be extended to provide advance shielding based on the length-of-need (see Section 5.6.4). However, at this time, the appropriate length-of-need for this application is unknown. Therefore, to address the criteria reflected in the LRFD specifications, it is recommended that the tall wall be extended 3 m [10 ft] in advance of the piers. Beyond this point, the barrier height should be vertically transitioned, on a 10:1 slope, to the height of the adjoining barrier used to shield the remaining length-of-need as described in Section 5.6. Another option to accommodate bridge piers not designed to withstand LRFD large impact loads is to shield the piers with a separate crash wall to accommodate the LRFD impact loads and then shield this system with a TL-3 longitudinal roadside barrier. Significant research is needed to develop more specific criteria to warrant the use of this tall barrier for pier protection. Transportation agencies can develop their own criteria based on factors such as project scope, route classification, ADT, geometry, bridge type, barrier offset, barrier/pier impact history, bridge type and configuration, and the roadway alignment.

On construction projects that retain an existing bridge, transportation agencies can evaluate the adequacy of the existing bridge pier and the appropriate test level barrier system to provide based on factors such as offset, roadway geometry, traffic composition, bridge type and configuration, and crash history. The implementation of the AASHTO LRFD specifications regarding this extreme column loading and barrier requirements may not be appropriate for existing bridges that were not originally designed using the AASHTO LRFD specifications. Each state can develop their own criteria for existing bridges to fit their conditions.

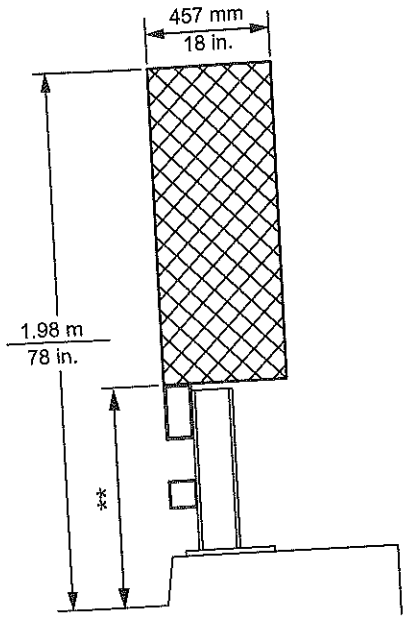


*Reviewed TL-2 concrete barrier heights fell in a range of 508 mm (20 in.) to 1.07 mm (42 in.)

Figure 5-27. Zone of Intrusion for TL-2

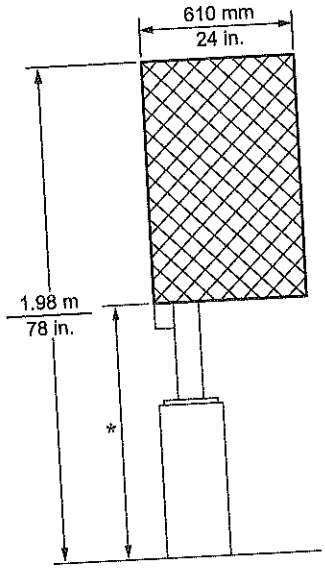


*Reviewed TL-3 sloped-face concrete barrier heights fell in a range of 762 mm (30 in.) to 813 mm (32 in.)

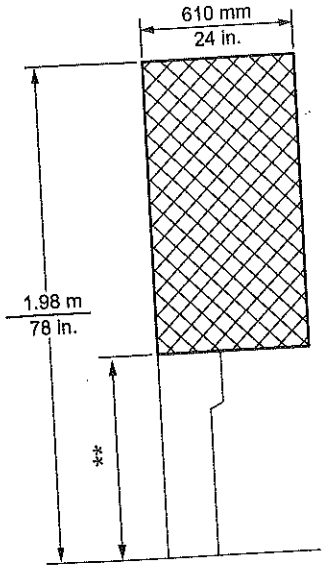


**Reviewed TL-3 steel tubular barrier on curb (curb greater than 152 mm [6 in.]) heights fell in a range of 813 mm (32 in.) to 864 mm (34 in.)

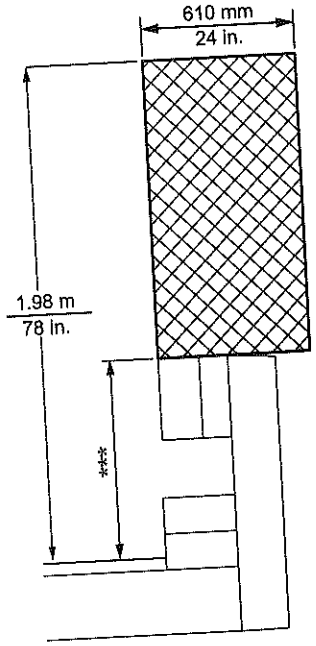
Figure 5-28. Zone of Intrusion for TL-3 Concrete Barriers and Steel Tubular Rails on Curbs



*Reviewed TL-3 combination barrier heights fell in a range of 889 mm (35 in.) to 1.07 m (42 in.)

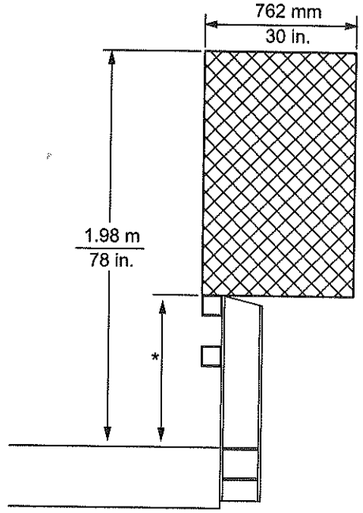


**Reviewed TL-3 vertical concrete barrier heights fell in a range of 737 mm (29 in.) to 813 mm (32 in.)



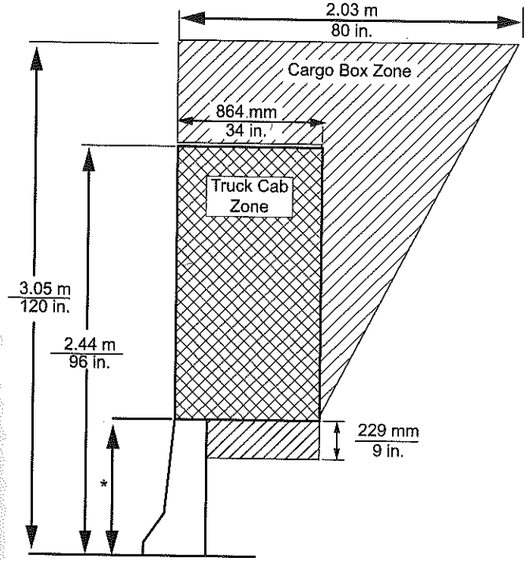
***The reviewed TL-4 timber barrier heights were 838 mm (33 in.)

Figure 5-29. Zone of Intrusion for TL-3 Combination and Timber Barriers



*Reviewed TL-3 steel tubular barrier (no curb or curbs 152 mm [6 in.] or less) heights fell in a range of 705 mm (27.75 in.) to 914 mm (36 in.)

Figure 5-30. Zone of Intrusion for TL-3 Steel Tubular Rails Not on Curbs



*Review TL-4 barrier heights fell in a range of 737 mm (29 in.) to 1.07 m (42 in.)

Figure 5-31. Zone of Intrustion for TL-4 Barriers per NCHRP Report 350