Figure 3.19: Steel-Backed Timber Turned Down

Figure 3.20: Steel-Backed Timber Buried in Backslope

Whenever a backslope is available a buried in backslope end treatment should be considered. A buried in backslope end is usually preferable because the end is not exposed, the length of need described in Chapter 4 is not an issue because the hazard is completely cut off, it is not as sensitive to side slope conditions and it is less expensive than most other end treatments. It may be appropriate to extend a barrier for a short distance in order to reach a backslope in order to take advantage of these benefits.

When selecting an end treatment the terrain surrounding the end and possible grading requirements should be considered. The following are issues that should be considered:

- Advance Terrain. The terrain in advance of the end should be flat (1V: 10H) and unobstructed. End treatments that require more flare will also require larger platforms of flat area around the end. Grading platforms built to accommodate the end treatment must be smoothly transitioned to the existing side slope so that the entire approach to the end remains traversable (1V: 3H or flatter).

- Adjacent Terrain. The area immediately around the end should be essentially flat and free of obstructions so that a vehicle striking the end will not be in a roll, pitch or yaw. Other devices, including those that are breakaway, should not be placed in this region. The recommended dimensions are shown in figures 8.1 and 8.2 of the *RDG*. Care must be taken to avoid building a slope steeper than 1V: 3H immediately upstream and behind the terminal in order to accommodate these dimensions. Extending the barrier to a flatter area may be the only solution in this case. This issue is not as important for ends that are buried in backslopes.

- Immediate Downstream Terrain. All of the end treatments, with the exception of those buried in a backslope, are gating terminals, meaning that an angular hit by a vehicle right at the end will result in the vehicle passing through the system. Generally the end will swing, or gate, around the third post. Therefore, a clear zone, traversable and unobstructed, should be available behind the end treatment. For high speed conditions this should be an area 20 meters (75 feet) long and 6 meters (20 feet) wide. At lower speeds, as much clear zone behind the end treatment should be provided as possible. The width should be at least consistent with that available on the approach to the end treatment. This issue is not important for ends buried in backslopes and may not be as important for the W-beam tangent end treatment.

3.5 TRANSITION SECTIONS

Another important component of a roadside barrier is the transition section. Transitions are necessary when a barrier is connected to another type of barrier system with a different dynamic deflection. A very common transition situation is a bridge approach barrier. When a barrier system transitions to another system with less deflection, as in the case of a strong post w-beam to a concrete bridge rail, the corner of the more rigid barrier must be shielded. This is accomplished by increasing the stiffness of the approaching system, generally through reduced post spacing and increased beam strength. Rubrail, extra beam depth from a thrie-beam or curb, is also needed in order to avoid the potential for a wheel snagging at the corner of the rigid rail.

When the more rigid system transitions to a less rigid system, as in the case of a downstream rail at the end of a bridge rail, the need is to ensure that the downstream system has adequate tensile strength at the connection.

Table 3.6 illustrates the various transition sections that are available.

Table 3.6: Transition Sections

Upstream Barrier	Downstream Barrier	Test Level	Reference
Three -Strand Cable (G1)	Strong Post W-Beam (G4)	TL-3	See Note Below
	Rigid Barrier	TL-3	See Note Below
High-Tension Cable (HTC)	Strong Post W-Beam (G4)	TL-3	See Supplier Data
	Rigid Barrier	TL-3	See Supplier Data
Weak Post W-Beam (G2)	Strong Post W-Beam (G4)	TL-2	See Note Below
	Rigid Barrier	TL-2	See Note Below
Box Beam (G3)	Strong Post W-Beam (G4)	TL-3	See Note Below
	Rigid Barrier	TL-3	See Note Below
Strong Post W-Beam (G4)	Thrie- Beam	TL-3	Manufactured Section
	Concrete Safety Shape (CSS)	TL-3	STD 617-27 and 28
	Vertical Concrete Wall	TL-3	STD 617-25 and 26
Thrie-Beam (G9) and Modified Thrie-Beam (G9M)	Concrete Safety Shape (CSS)	TL-3	See Note Below
	Vertical Concrete Wall	TL-3	See Note Below
Steel-Backed Timber (SBT)	Stone Masonry Guardwall (SMG)	TL-2	STD 617-64
	Stone Masonry Guardwall (SMG)	TL-3	STD 616-65
	Curved Back Vertical Wall	TL-3	STD 617-66
	Straight or Curved-End Structure	TL-2	STD 617-68

Note: Transition details are available in various State DOT standard drawings.

Figure 3.21: W-Beam Transition

Figure 3.22: W-Beam to Thrie-Beam Transition

3.6 EXAMPLE PROBLEMS

The following are example applications of the barrier selection process described in this chapter.

Problem 1. This problem is the same as Problem 1 of Chapter 2.

Roadway data: A two-lane road, with 3.6 m (12 ft) lanes and 1.2 m (4 ft) paved shoulders. There is a tangent section and a 46 m (150 ft)-long horizontal curve on a 240 m (800 ft) radius. The whole section is on a 3 percent downward grade.

Traffic data: Present ADT is 400 with a 3 percent annual growth factor. Design speed is 50 km/h (30 mph). On the tangent section actual speeds may exceed the design speed.

Hazard data: The hazard is a 1V: 2H foreslope 18 m (60 ft) high; offset is 1.8 m (6 ft) from the edge of traveled way on the outside of the horizontal curve. The slope is 150 m (500 ft) parallel to the road, including both the horizontal curve and the tangent section. There are some scattered trees and small boulders on the slope.

Other issues: Because of the remote location, barrier construction is expected to be costly. There is no crash data available. There are no aesthetic or environmental issues.

Previous Recommendations: A barrier is warranted on both the tangent and horizontal curve sections.

Solution: Neither aesthetics nor severe conditions are the overriding concerns in this situation, so Table 3.2 applies. The available hazard offset is 1.8 m (6 ft) from the edge of traveled way. For 50 km/h (30 mph), the following barriers are technically acceptable: HTC, G2, G3, G4 and G9. Of these systems, the client agency only uses the G4 and G9. The G4 is the least expensive and is therefore the selected barrier.

Problem 2. This problem is the same as Problem 2 of Chapter 2.

Roadway data: A two-lane road, with 3.6 m (11 ft) lanes and .4 m (2 ft) paved shoulders. This is a flat and tangent section. The roadway approaches a bridge across a river. On the approach the road leaves a cut section and approaches the bridge on a fill with 1V: 3H side slopes. The slope break for the fill is 0.6 m (2 ft) from the edge of the shoulder. The fill is approximately 2.4 m (8 ft) high. On the far side a similar fill extends 60 (200 ft) where the fill flattens to 1V: 4H. There are no pavement markings on the road or the bridge.

Traffic data: Present ADT is 1,100 with a one percent annual growth factor. Design speed is 70 km/h (45 mph).

Hazard data: An 8.5 m (28 ft)-wide bridge crosses a river with water depths of approximately 1.5 m (5 ft). The bridge rail is a vertical concrete wall.

Other issues: This roadway is in a park with serious aesthetic concerns.

Previous Recommendations: The clear zone is 11.9 m (39 ft). A barrier is warranted on the near sides of both approached to the bridge.

Solution: Aesthetics is an important issue in this case, so Table 3.3 applies. The available hazard offset is 1.0 m (3 ft) from the edge of traveled way. For 70 km/h (45 mph), SBL and SBT barriers are technically acceptable. The SBL system, a TL-2 system, does not have a transition design available so the SBT system is recommended.