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Town of Weston

Guardrail Overview Report

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EXECUTIVE SUMMARY

Installation of guardrails requires careful consideration and design. Improperly sited or designed guardrails can increase the severity of potential accidents, which in turn can increase the liability of the owner or installer of the guardrail. Guardrails should only be installed in locations where there is specific criteria that justifies the installation. In traffic engineering, a particular set of criteria that is used to determine whether an improvement, such as a traffic signal or guardrail, is justified is called a warrant. The proposed improvement can only be recommended by the traffic engineer if all the criteria of the warrant are met.

The Roadside Design Guide (3rd edition, 2006, AASHTO) states that a cost benefit analysis can be used to evaluate whether a barrier is warranted. Costs associated with the barrier installation (installation costs, maintenance costs and accident costs) are compared to similar costs without barriers. The cost benefit analysis is typically used to evaluate three options: 1) remove or reduce the area of concern so that it no longer requires shielding, 2) install an appropriate barrier, or 3) leave the area of concern unshielded. Guardrails or other roadside barriers should only be installed where, after careful review, a warrant requires their installation. Once it is established that a guardrail is warranted, design procedures, as detailed in Chapter 5 of the Roadside Design Guide, need to be followed to ensure that the barrier installed is appropriate for the location. Special consideration has to be given to the design of the ends of the barriers (often referred to as the terminal ends) so that vehicles leaving the traveled way do not impact the end of the barrier head on.

Taking into account cost and aesthetics of the preferred barrier systems (listed in decreased order of preference) are:

No Barrier

No barrier should be provided unless warranted and the barrier installation, including end treatments, has been properly designed. Prior to the design and installation of any barrier system, the area of concern should be reviewed to see if the hazard can be reduced or removed.

Cable Guardrail

Cable guardrail has the lowest initial cost and is the least visually intrusive of all the barrier options.

Wood Guardrail with Steel Plate Backing

Wood guardrail is less visibly intrusive than metal guardrails but has a higher initial cost. However, guardrail installations in Weston are typically only for limited lengths. For a typical 50-foot-long installation, a wood guardrail would be approximately $1,400 more than a galvanized steel guard rail.

Corten Steel

Corten steel guardrails are slightly less visibly intrusive than galvanized steel guardrails. Corten steel guardrails cost 10-15% more than galvanized steel.

Galvanized Steel

Galvanized Steel is the most visibly intrusive barrier system and costs twice as much as a cable guardrail system.

Table of Contents

1 INTRODUCTION 1

2 GUARDRAIL DESCRIPTIONS 2

2.1 Steel Galvanized Guardrail 2
2.2 Corten Steel Guardrail 3
2.3 Wood Guardrail with Steel Plate Backing 4
2.4 Cable Guardrail 5

3 PROS AND CONS 6

3.1 Steel Galvanized Guardrail 6
3.2 Corten Steel Guardrail 6
3.3 Wood Guardrail with Steel Plate Backing 7
3.4 Cable Guardrail 7

4 COSTS 9

4.1 Steel Galvanized Guardrail 9
4.2 Corten Steel Guardrail 9
4.3 Wood Guardrail with Steel Plate Backing 9
4.4 Cable Guardrail 9

5 SUMMARY 90

List of Figures

Figure 1 – Steel Galvanized Guardrail 3
Figure 2 – Corten Steel Guardrail 3
Figure 3 –Wood Guardrail with Steel Plate Backing 4
Figure 4 – Cable Guardrail 5

1 INTRODUCTION

Nitsch Engineering has been retained by the Town of Weston to prepare an overview of four types of guardrails: steel galvanized guardrail, corten steel guardrails, wood guardrails with steel plate backing, and cable guardrails. This report will examine each type of guardrail, the pros and cons, and the costs associated with each type of guardrail.

2 DESCRIPTION

Traffic barriers are used to prevent errant vehicles from leaving the traveled way and from colliding with objects that have a greater crash severity potential than the barrier itself. Traffic barriers may also be used to protect bicyclists and pedestrians from vehicular traffic. Since traffic barriers introduce an additional potential object to crash into, their placement should be carefully considered. Traffic barriers include longitudinal barriers and crash cushions. The function of longitudinal barriers is to redirect errant vehicles while the purpose of crash cushions is to decelerate errant vehicles to a stop. Guardrails are classified as a longitudinal barrier. There are three types of longitudinal barriers: flexible, semi-rigid, or rigid. The main difference in these types of barriers is the amount of deflection that they undergo upon vehicle impact. In selecting a barrier, the designer should refer to current warrants and criteria for determination of barrier needs.[1]

2.1 Steel Galvanized Guardrail

Steel galvanized guardrail can be classified as a flexible or semi-rigid system depending on the types of posts used. In a semi-rigid guardrail system, strong posts are used and resistance is achieved through the combined flexure and tensile strength of the rail. The posts, by the point of impact, are designed to break or tear away, which in turn distributes the impact force by beam action to adjacent posts. The posts outside of the impact zone provide sufficient resistance to control the deflection of the beam to an acceptable limit and redirect the errant vehicle along the path of traffic flow. Flexible systems use weaker posts and are generally more forgiving than semi-rigid systems since much of the energy is absorbed by the deflection of the barrier and lower impact forces are imposed upon the vehicle. Steel galvanized guardrail systems may retain some degree of effectiveness after minor hits due to the rigidity of the rail element. Guardrail systems may or may not have a block installed between the post and the rail. When guardrail has a block installed between the post and the guardrail, it is called a “blocked-out” guardrail. The blockout minimizes vehicles snagging and reduces the likelihood of a vehicle vaulting over the barrier by maintaining rail height during the initial stages of post deflection. Blockouts are typically of the same material as the posts but can also be made from recycled plastics.

Steel beams often come in W-Beam or Thrie-Beam shapes. W-Beam steel guardrail with strong posts is the most frequently used type of guardrail on the nation’s interstate roadway system. It is a roll-formed product that is shaped out of steel coil into the shape of a “W.” The galvanized steel prevents corrosion and increases the product’s life cycle. Strong post W-Beam guardrail can be installed on steel W6x8 or W6x8.5 posts or 6x8 timber posts, using a variety of different post spacing options, depending on the specific site situation (typically 6’-3” spacing). W-Beam guardrail can be ordered with the traditional galvanized (gray) coating, corten style (see description below), or poly-coated in a variety of colors to match specific aesthetic criteria. W-Beam guardrail comes in standard 12’-6” or 25’ sections. Steel guardrail is recommended for use on high-speed roadways (greater than 35 miles per hour), although it can also be installed on low-speed roadways. The main difference between a W-Beam rail and a Thrie-Beam rail is that the Thrie-Beam rail has added depth of rail that can accommodate a greater range of vehicle sizes and can negate some of the problems associated with minor terrain irregularities. The additional corrugation in the rail element stiffens the system, making it less prone to damage during vehicle impacts. It also allows higher mounting of the rail, which increases its ability to contain vehicles somewhat larger than standard passenger vehicles. The deeper beam will minimize the possibility of underride or vaulting by impacted vehicles. See Figure 1 for an example of steel galvanized W-Beam guardrail with steel posts.

Figure 1 – Steel Galvanized Guardrail

2.2 Corten Steel Guardrail

Corten steel guardrail functions the same as the steel galvanized guardrail, as discussed above. The main difference between the steel galvanized guardrail and corten guardrail is that the corten guardrail is a brown "rust" color and, under certain circumstances, deteriorates quicker than steel galvanized guardrail. The Federal Highway Administration (FHWA) states that the use of corten guardrail should be limited due to possible deterioration concerns.[2] Because roadside barriers are usually close enough to the path of travel that they might be sprayed with water from passing vehicles, chemicals found in the water spray can affect and degrade the structural integrity of corten steel. It is recommended that an inspection and replacement schedule be put in place for steel corten guardrails. The steel corten guardrail is primarily used for its aesthetic values. See Figure 2 for an example of steel corten guardrail.

Figure 2 – Corten Steel Guardrail

2.3 Wood Guardrail with Steel Plate Backing

Wood guardrail with steel plate backing is classified as a semi-rigid system and was developed as an aesthetic alternative to conventional guardrail systems. The system consists of a longitudinal wood rail backed by a steel plate installed on heavy wood posts. The steel plate provides needed tensile strength to the system. The wood members provide a more rustic appearance than the steel normally used in barriers. This type of railing is often specified for use along roads under the jurisdiction of the National Park Service and similar agencies. Wood guardrail is recommended for use on low volume roadways with design speeds under 55 miles per hour. End treatments are a design consideration for wooden guardrails. Ideally the end treatment would consist of a transition to buried section of guardrail that is also flared away from the road surface. If sufficient space is not available to flare the guardrail away from the road then just the transition to a buried section is acceptable. Refer to Figure 3 for an example of wood guardrail with steel plate backing installed along Route 117 in Lincoln near the Concord town line.

Figure 3 –Wood Guardrail with Steel Plate Backing

2.4 Cable Guardrail

Cable guardrail is classified as a flexible barrier system. A flexible barrier system undergoes considerable deflection upon impact and imposes lower impact forces on the vehicle than semi-rigid and rigid systems. The resistance of cable guardrail systems is derived from the tensile force in the cable. Within the impact zone, the post offers negligible resistance as the cables tear away from the post upon impact. However, the posts outside the impact zone offer sufficient resistance to keep the deflection of the cable within an acceptable limit. This guardrail system is designed primarily to contain rather than redirect the vehicle and needs more lateral clearance from fixed objects due to the deflection during impact. Cable guardrail is suitable for use on flat or moderately sloped terrain and is an ideal choice in areas where there is sufficient deflection area. Cable systems are also appropriate in areas that have low to moderate traffic speeds (35 mph and lower) and volumes and have clear space beyond the edge of the roadway. A cable guardrail should be used only if adequate deflection distance exists to accommodate approximately 12 feet of movement, however, shortening the post spacing can reduce deflection distances.[3] The deflection of a high-tension cable guardrail system can be in the range of 6.6-9.2 feet depending on the system and post spacing.[3] The high-tension systems also result in less damage to the barrier and, in many cases, the cables remain at the proper height after an impact that damages several posts. The posts can be installed in sleeves in the ground to facilitate removal and replacement. Typical end treatment for cable guardrails is a transition to buried cables that flare away from the traveled way. If space constraints don't allow for a flare away from the roadway than just the transition to the buried cable is acceptable.

After an impact, repairs to the cable guardrail system can include reinstalling posts, reattaching cables, re-tensioning cables, and/or replacing cables. The repairs necessary depend on the characteristics of the crash (size of vehicle, speed, angle of impact).

On-going maintenance of cable guardrail systems include inspecting and maintaining specified cable heights and correct cable tension, as well as ensuring proper functioning of cable connectors and end anchors. If cable barriers have been designed and installed correctly, they require little on-going maintenance. Refer to Figure 4 for an example of a cable guardrail system.

Figure 4 – Cable Guardrail

3 PROS AND CONS

3.1 Steel Galvanized Guardrail

Pros:

- Has a zinc coating protecting the steel from rust and corrosion, giving it an extended lifespan when exposed to the elements.
- Can maintain a degree of effectiveness after minor hits due to the rigidity of the rail, thereby eliminating the need for immediate repair.
- Can use wood or steel posts.
- Strong post barriers require less clear area behind them when compared to flexible barrier systems.
- Less expensive than steel corten guardrail.

Cons:

- Based on individual site characteristics, this type of guardrail may not be the most visually pleasing alternative.
- Strong post barriers generally cause higher forces on impacting vehicles and their occupants than do flexible systems.

Potential Locations

Steel galvanized guardrail is a more industrial looking material and does not blend into a wooded background as easily as other materials. Several areas in Weston immediately adjacent to off-ramps may be appropriate locations for the use of galvanized guardrail. Areas such as Park Road near the on/off ramp to the Turnpike or areas immediately adjacent to the Route 20/95 interchange are examples where the use of steel galvanized guardrail may be acceptable. These areas have large volumes of traffic and do not project a rural character, and they are adjacent to areas under state control that already have steel galvanized guardrail.

3.2 Corten Steel Guardrail

Pros:

- Often more aesthetically pleasing due to its brown “rust” colored guardrail, especially in parks or other natural environments.
- Can maintain a degree of effectiveness after minor hits due to the rigidity of the rail, thereby eliminating the need for immediate repair.
- Can use wood or steel posts.
- Strong post barriers require less clear area behind them when compared to flexible barrier systems.

Cons:

- Will need to be repaired and/or replaced more often than steel galvanized guardrail. It is recommended that an inspection and replacement schedule is put in place if this material is used.
- Strong post barriers generally cause higher forces on impacting vehicles and their occupants than do flexible systems.
- Approximately 10-15% more expensive than steel galvanized guardrail.

Potential Locations

Corten steel guardrail provides a similar level of protection as galvanized steel guardrail but has a much more subdued look that blends in much more easily in a wooded background. Corten steel guardrail would be appropriate in Weston in areas that already have (or are looking to keep) their rural/wooded character. Ideally,

to maintain or extend its surface life, it would be used in locations that are not directly adjacent to the traveled way so as to minimize exposure to salt spray.

3.3 Wood Guardrail with Steel Plate Backing

Pros:

- The wood members provide a more rustic appearance than the steel and concrete normally used in barriers.

Cons:

- Relatively expensive when compared to the other three alternatives.
- Because only the full height straight sections have been crash tested, this system must transition to other approved systems at termini and on sharp curves.[4]

Potential Locations

Wooden guardrail with steel backing blends in more easily into a wooded/rural background. As noted, roadways with sharp curves or other areas that require a tight radius for the guardrail would not be appropriate locations. Wooden guardrail is a popular choice in rural/rustic areas and can be found in numerous locations in neighboring towns with a similar character as Weston (i.e. Lincoln, Concord, and Sudbury). Figure 3 shows a wooden guardrail installation on Route 117 in Lincoln near the Concord River Bridge.

3.4 Cable Guardrail

Pros:

- Lowest cost when compared to the other three alternatives.
- Effective vehicle containment and redirection over a wide range of vehicle sizes and installation conditions.
- Lower deceleration forces upon the vehicle and occupants when compared to semi-rigid barrier systems.
- Advantageous in snow or sand areas because its open design prevents drifting on or alongside the roadway.
- Visually unobtrusive, aiding visibility and forming a visually attractive alternative to heavier guardrail systems.
- Facilitates snow removal as snow can be pushed through the cables.

Cons:

- Comparatively long lengths of barrier that must be replaced following an impact for the system to maintain effectiveness.
- The clear area needed behind the barrier to accommodate the design deflection distance is greater when compared to semi-rigid barrier systems.
- Reduced effectiveness on the inside of curves.
- Sensitivity to correct height installation and maintenance.
- At high speeds, cable guard rail systems can cause vehicles with high centers of gravity, such as sport utility vehicles, to roll over. Alternatively, low weight vehicles can hit a slack cable system and “trampoline” back into traffic causing multi-vehicle crashes.

Potential Locations

Cable guardrail provides a low-cost, effective barrier system that is also the most visibly unobtrusive. Appropriate locations in Weston would include areas where there is a desire to maintain the rural character. Cable guardrails with wood posts have been installed in numerous locations throughout neighboring communities that have similar character to Weston. The accompanying photo (Figure 4) was taken at a recent installation of cable guardrail located on Trapelo Road in Lincoln.

4 COSTS

The following summarizes the costs associated with each type of guardrail.

4.1 Steel Galvanized Guardrail

The costs for steel galvanized guardrail systems include the steel W-Beam guardrail, steel posts, steel or wood offset blocks, and terminal sections. The approximate cost per linear foot of steel galvanized guardrail with steel posts is $43 dollars (from MassDOT bid prices).

4.2 Corten Steel Guardrail

The corten steel guardrail system consists of the same components of a steel galvanized guardrail except for the rail. The cost for corten steel guardrail systems is $47 to $50 per linear foot, or approximately 10-15% more than the costs for steel galvanized guardrail systems. Due to the corrosive properties of corten steel guardrail, it will also need to be replaced more often than steel galvanized guardrail, and, therefore, has a higher life cycle cost.

4.3 Wood Guardrail with Steel Plate Backing

The costs for wood guardrail with steel backing include the wood rail, posts, blocks, steel back plates, and terminal sections. The approximate cost per linear foot of wood guardrail with steel plate backing and wooden posts is $71 dollars. Wood guardrail with steel plate backing is more expensive than steel galvanized guardrail due to the wood rail and wood posts being more expensive than steel rail and steel posts. The steel back plates are also an added cost that steel galvanized guardrails do not require.

4.4 Cable Guardrail

The costs for cable barriers installed by the Massachusetts Department of Transportation (MassDOT) averages $32 per linear foot. Due to the higher speeds seen on MassDOT roads a three or four cable assembly is typically installed. A two cable assembly suitable for a lower road speeds (as shown in Figure 4) would be in the range of $24 to $28 per linear foot.

5 SUMMARY

Each type of barrier system has its pros and cons, and when it comes to longitudinal barrier systems, a “one size fits all” approach cannot be employed. Barrier systems add an additional maintenance burden on their owners, and, when improperly sited, can create an increased hazard to the general public. Carefully documenting the need for a barrier through the use of accident data and site evaluation should done before any installation is considered.

Depending on the individual site and roadway characteristics, any of the four barriers discussed in the report may be the optimal choice. The most important factors to be considered when selecting a barrier system, either for a new barrier, or replacement of an existing barrier, are performance capability, deflection, site conditions, compatibility, cost, aesthetics, and maintenance (both routine and collision). Out of the four alternatives, the

least expensive system to install is the cable system, the second least expensive system is the steel galvanized guardrail system, the third least expensive system is the corten steel guardrail system, and the most expensive system is the wood guardrail with steel plate backing system. As the cable guardrail system is also the most visibly unobtrusive system, it is the Weston Planning Board's preferred alternative where the site conditions allow it. The AASHTO Roadside Design Guide should be consulted for more detailed information on the selection, design, and installation of barrier systems.

References & Further Information

- [1] 2011 AASHTO *A Policy on Geometric Design of Highways and Streets*
- [2] Federal Highway Administration (FHWA) Memorandum, ACTION: Roadside Design: Steel Strong Post W-Beam Guardrail, May 17, 2010
- [3] 2011 American Association of State Highway and Transportation Officials (AASHTO) *Roadside Design Guide*
- [4] *2*006 Massachusetts Department of Transportation (MassDOT) *Project Development and Design Guide*
- [5] The National Cooperative Highway Research Program (NCHRP) Report 711 *Guidance for the Selection, Use, and Maintenance of Cable Barrier Systems, 2012*

Guardrail Decision Tree for New Barriers or Replacement of Existing Barriers