Title: IMPROVED GUARDRAIL TERMINALS

Abstract: Devices and methods for supporting guardrail terminal installations that incorporate safety end treatments such as the GET and the SRT. Preferred embodiments are described wherein guardrail terminal installations are primarily anchored to the ground using weak support posts that are preferably made of metal. The ends of the guardrail installation are secured to the ground using breakaway posts. In operation, the weak posts permit the central portion of the guardrail installation to contain and redirect the vehicle during a lateral collision to the rail member. The anchorage provided by the breakaway end posts helps prevent the guardrail from being excessively displaced, thus preventing the impacting vehicle from breaking through the guardrail. In operation, guardrail terminal assemblies constructed in accordance with the present invention provide an improved support system for the rail member which is more forgiving than conventional strong post anchorages, thereby providing an improvement in safety.
IMPROVED GUARDRAIL TERMINALS

BACKGROUND

1. Field of the Invention

The present invention generally relates to improvements for guardrail terminal installations and, in particular aspects, the invention relates to improved support posts and support systems for guardrail terminal systems that have safety end treatments.

2. Description of the Related Art

An important aspect of guardrail design is the ability of the guardrail to resist rupture and prevent penetration of the rail by a vehicle that impacts the guardrail end. For that reason, conventional guardrail installations are provided along their lengths with “strong” support posts that provide very little give when impacted by a vehicle. “Strong” support posts include 7” diameter wood posts, W6x9 steel section posts and 6” by 8” wood posts.

Recently, it has also become important that a guardrail installation not present a hazard to a vehicle during an “end-on” impact where the guardrail installation is impacted from its end by a vehicle. As a result, a number of solutions have been proposed and used for eliminating the upraised end of the guardrail for making it safer.

The guardrail extruder terminal (GET) and slotted rail terminal (SRT) are known safety end treatments for a guardrail assembly that permit the guardrail assembly to safely absorb some or all of the vehicle’s kinetic energy during an end-on collision, thereby eliminating the hazard associated with the upraised end. These end treatments are desirable because they absorb the energy of an end-on collision in a controlled manner to help bring an impacting vehicle to a safe stop or they allow the vehicle to safely “gate” through the terminal after absorbing some of the vehicle’s energy. The GET is described in U.S. Patents 5,078,366 and 4,928,928. The SRT is described in U.S. Patents 5,547,309 and 5,407,298. Those patents are incorporated herein by reference. These end treatments were originally designed so that the support posts of the terminal would be readily frangible, “breakaway” posts made of wood. Holes were usually drilled
through the post near the ground line in order to weaken the post at that point. Guardrail support posts downstream from the terminal are typically solid wooden posts used to securely anchor the midpoint of the guardrail assembly to the ground. As the guardrail collapsed or became flattened by the end treatment, the breakaway posts would be broken at or around the ground line.

There are, however, drawbacks to using strong posts along the length of the end-treatment terminal. The strong posts must be weakened in some manner to accommodate end on impacts to the terminal. These modifications are costly and time consuming and, if done improperly or forgotten, can result in a significant safety hazard for motorists.

The inventors believe that, to date, guardrail terminals have used entirely strong support posts that have been modified by drilling holes or using other means to cause the post to breakaway. An improved guardrail installation would be desirable.

**SUMMARY OF THE INVENTION**

The present invention provides new and innovative devices and methods for supporting guardrail in guardrail terminals that incorporate safety end treatments such as the GET and the SRT. Preferred embodiments are described wherein the guardrail in a terminal is primarily supported above the ground using weak support posts that are preferably made of metal. The ends of the terminal installation are secured to the ground using breakaway posts and other accessories.

In operation, the weak posts in the downstream portion of the guardrail installation help to contain and redirect a vehicle during a lateral collision to the rail member. The anchorage in part provided by the breakaway end posts helps prevent excessive guardrail displacements that will allow the impacting vehicle to pass over to the opposite side of the guardrail during side or lateral impacts along the length of the terminal.

In other aspects, the invention provides an alternative to use of post weakening mechanisms which results in savings of costs. In operation, terminal assemblies constructed in accordance with the present invention provide an improved support system
for the rail member which is more forgiving than conventional strong post support systems, thereby providing an improvement in safety.

At the present time, the invention has particular application in some non-U.S. countries, where it is required or highly preferred that metal support posts be used either completely or primarily within guardrail installations. However, the invention is also applicable to installation within the United States.

**BRIEF DESCRIPTION OF THE DRAWINGS**

Figure 1 is an overall plan view of an exemplary guardrail system constructed in accordance with the present invention having a guardrail extruder terminal-type end treatment.

Figure 2 is a perspective view of the upstream end of the exemplary guardrail system illustrated in Figure 1.

Figure 3 is a cutaway detail illustrating interconnection of the rail member to a support post.

Figure 4 is a plan view illustrating disconnection of a weak support post from the rail member during an end-on collision.

Figure 5 illustrates an exemplary S3 x 5.7 steel section post supporting a rail.

Figure 6 depicts an alternative guardrail installation constructed in accordance with the present invention and having a slotted rail terminal-type end treatment.

**DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS**

Referring initially to Figures 1 and 2, there is shown an exemplary guardrail assembly 10 that is constructed in accordance with the present invention. The guardrail assembly 10 runs longitudinally along a section of roadway 12 and has a first, upstream end 14 and a second, downstream end 16. Although the guardrail installation 10 is depicted as being disposed along a straight line, it will be understood that it may be curved as well to conform to the shape of the roadway 12 and may be made of any desired length. The guardrail installation 10 has a central standard guardrail section 11 with guardrail safety end terminals 13 located on either end of the standard section 11. The boundaries between the terminals 13 and the standard guardrail section 11 are
illustrated by lines 15 in Figure 1. The standard section 11 includes a corrugated rail 17 that is supported, in most instances, by strong posts 19.

Each of the guardrail terminals 13 include a substantially continuous, corrugated rail 18 that is supported at its end 14 or 16 by a pair of support posts 20. The rail 18 is supported in each terminal 13 by support posts 22.

Figure 2 depicts the upstream end 14 of one of the guardrail terminals 13 in greater detail. It is noted that the construction and operation described for the upstream end 14 is representative of both the upstream and downstream ends 14, 16. Figure 2 illustrates that the rail 18 is made up of corrugated rail members 24, 26 that are interconnected, or spliced, to one another using nut and bolt assemblies 27.

Each terminal 13 of the rail installation 10 includes a safety device, generally depicted at 28 in Figure 2 which is used to reduce the hazard associated with an upraised guardrail end. In this embodiment, the safety device 28 provides a guardrail extruder terminal impact head 30. The structure and operation of these type of terminal heads 30 is generally described in U.S. Patents No. 5,078,366 and 4,928,928. Figures 2 and 4 illustrate the fact that the traffic side 32 of the head 30 has reduced profile as compared to the non-traffic side 34 of the head 30. The head 30 is composed of an impact portion 36 and a feeder chute 38 that fits over the end of the rail 18. As Figure 4 shows, the head 30 encloses a throat 40 that receives the rail 18 and helps flatten the corrugations in the rail 18. Additionally, the head 30 includes a curved bending plate 42 that bends and further flattens the rail portion 18, displacing it laterally away from the head 30. Figure 4 illustrates a flattened portion 44 of the rail 18 being displaced laterally away from the head 30.

Preferably, up to three types of support posts, 20, 22, and 19 may be used to support the rails 17 and 18. Moving downstream from the impact head 30 along the terminal 13, the first two support posts 20 (only one shown in Figure 2) are breakaway post members that provide secure anchorage of the rail 18 to the ground 46. The anchorage provided by the support posts 20 is required for redirection of vehicles that might impact the rail assembly 10 from the side proximate the end 14.
A tension cable assembly 48 (shown in Figure 2) is disposed through the lead breakaway post 20. Tension cable assemblies such as assembly 48 are well known in the art and operate to transmit tensile forces applied laterally to the rail 18 to the lower end of the lead support post 20. As a result, the force from lateral impacts to the rail 18 are, in part, transmitted to the lower end of the support posts 20 at either end 14, 16 of the installation 10. This helps to securely anchor the rail 18 during such lateral impacts.

The support posts 20, which are the one or two most extreme posts at either end 14 or 16 of the installation are, as noted, frangible or breakaway in nature. During an end-on impact, then, the support posts 20 will easily breakaway near the ground line of the post 20 to release the rail 18 from its anchorage. When the lead post 20 broken away, the cable assembly 48 will also be released from its attachment to the post 20. There are a number of post structures that are suitable for use as breakaway posts 20. In certain, non-U.S. countries, for example, it is desirable and sometimes required to use non-wooden posts for guardrail installations. Thus, a breakaway steel post assembly would be particularly desirable. One example of a suitable steel breakaway post is described in U.S. Patent No. 5,988,598. Another suitable steel breakaway post is the HBA post, which is marketed commercially by Trinity Industries of Dallas, Texas. In other instances, a wooden breakaway post may be used, although this is not preferred, particularly in many non-U.S. countries where the use of wooden support posts must be minimized or eliminated. The structure and operation of wooden breakaway posts is known and described in U.S. Patent No. 5,547,309.

Posts 22 located along the length of each terminal 13 downstream from posts 20 along assembly 10, are unmodified yielding, or “weak,” support posts. The term “unmodified,” as used herein, refers to a post that has not been subjected to any weakening mechanisms, whether by mechanical, chemical or other means, such as by drilling holes in the post, by notching the post, by incorporating mechanical breakaway devices such as frangible connections, or by incorporating bolts that shear upon impact. The unmodified weak post, by its inherent cross-sectional properties and material properties, readily yields or is deflected in a collision. It is preferred that the weak posts
be formed of metal rather than of wood. An unmodified “weak” support post is a support post that readily yields or is deflected in a collision. Further, an unmodified weak support post is one that will meet “preferred” occupant impact velocity and occupant ride-down acceleration limits, as recommended in NCHRP Report 3501 or its successor, when impacted in a direction consistent with the direction it would be impacted in end-on tests of a guardrail terminal by design vehicles recommended in NCHRP Report 3501 or its successor, traveling at speeds of approximately 15 mph or greater with the post embedded in soils as recommended in NCHRP Report 3501 or its successor. Weak support posts are further characterized by a greater amount of deflection upon impact than strong posts.

In addition, an unmodified weak guardrail post is one that will meet Impact Severity Class A, as specified in CEN prEN 1317-4, Trento, June 1999, or its successor, when impacted in end-on tests of a guardrail terminal by test vehicles specified in CEN prEN 1317-4, Trento, June 1999, or its successor, traveling at speeds or approximately 25 km/h or greater, with the posts embedded in soils as recommended in CEN prEN 1317-4, Trento, June 1999, or its successor.

Examples of commercially available unmodified weak posts are 4" diameter circular wood posts, 4" x 6" rectangular wood posts and S3 x 5.7 steel section posts. It is preferred, particularly for application in many non-U.S. countries, that the weak posts comprise either C-120 or S3 x 5.7 steel section posts since these posts are not made of wood. Presently, it is highly preferred that the weak posts 22 comprise a C-120-type post, which is a standard Spanish support post. A C-120 post is illustrated in Figures 2, 3 and 4. It can be seen that the C-120 post has a U-shaped cross-section. This U-shape provides a shorter, weak axis running parallel to the two legs 23 of the post 22, and a longer, strong axis running parallel to the cross-member 25 of the post 22. The C-120 post is, therefore, more easily bent in the direction of the weak axis than in the direction of the strong axis. As a result, the C-120 post has the advantageous property of yielding more easily in response to an end-on impact than to a lateral impact upon the rail 18.
Figure 5 illustrates an embodiment of the invention wherein the rail 18 is being supported by unmodified posts 22' that comprise S 3 x 5.7 steel section post members. The S 3 x 5.7 steel section post has an H-shaped cross-section made up of a central web 27 and two end flanges 29. Two connectors 31 are used to affix the rail 18 and bracket 50 to one of the end flanges 29. As can be seen, the S 3 x 5.7 post provides the same sort of weak and strong axes as the C-120 post member, and it will also provide the advantage of more readily yielding in response to an end-on collision than a lateral impact to the rail 18.

Posts 19 located along the central portion of the guardrail installation may be the same as posts 22 or 22', or they may be different in size, shape or material.

Figures 2 and 3 illustrate the details of attachment of the rail 18 to a C-120 post 22. A U-shaped standoff bracket 50 is disposed between the rail 18 and each post 22. The U-shaped bracket 50 has a central web 52 and two legs 54, as Figure 3 shows. The bracket 50 is located so that the rail 18 is engaged by portions of the web 52 and each leg 54. A connector 56, such as a nut-and-bolt assembly, is disposed through the post 22, bracket 50 and rail 18 to securely affix the rail to the post 22. The legs 54 of the bracket 50 provide stiffness to the rail 18 and help to distribute the force of a lateral impact upon different areas of the support post 22. In testing, the presence of the bracket 50 has been shown to reduce the amount of deflection of the rail 18 in response to a lateral impact.

Therefore, the brackets 50 compensate somewhat for the weakness of the weak support posts 22 and help ensure that a laterally impacting vehicle will not rupture or penetrate the rail 18. In a preferred embodiment of the invention, the support posts 22 that are located 3rd, 5th and 7th from each end 14, 16 of the rail assembly 10 are not affixed to the rail 18 with connectors. This makes it easier for the rail 18 to feed properly into the impact head 30 since the rail is typically spliced together at these posts. An example of a splice in the rail 18 is shown in Figure 2 where rail members 24 and 26 are joined by connectors 27.

Figure 4 depicts the release of the rail 18 from a weak support post 22 during an end-on impact. As shown there, the impact head 30 has received an end-on impact from
vehicle 58 that has driven the head 30 down along the rail 18 thereby flattening and
displacing the rail 18 to provide flattened portion 44. In the position shown, the head 30
has traveled downstream past the locations of the two breakaway posts 20. The feeder
chute 38 of the head 30 has contacted the bracket 50 and the connector 56 passing
through the bracket 50 that interconnects the rail 18 to the post 22. The feeder chute 38
has released the connection. Typically, the connection is released as the connector 56 is
pulled through the rail 18. It is noted that the bracket 50 provides a surface upon which
the downstream end of the feeder chute 38 is contacted during the downstream movement
of the head 30. The weak support post 22 will later be bent down from the rail 18 by the
impact portion 36 and vehicle 58. The unmodified weak post 22 typically yields by
bending proximate the point at which it is buried in the ground. This bending down is
very advantageous as it permits support posts to be readily bent down permitting the
impacting vehicle 58 to easily traverse the post in the collision.

Referring now to Figure 6, a second embodiment of the invention is described.

Like components between the two embodiments are numbered alike. Guardrail
installation 100 includes a rail-collapsing slotted rail terminal (SRT)-type end treatment
102 at its upstream end 14. The construction and operation of SRT end treatments is, as
noted previously, described in U.S. Patents 5,547,309 and 5,407,298. The SRT end
treatment 102 features several slotted sections 104 (only one shown) in the rail 18. The
20 slotted section 102 contains three longitudinal slots 106 that are cut into the rail 18 to
weaken its ability to structurally withstand an end-on impact. Slot guards 108 are located
at the downstream end of the slots 106.

The guardrail installation 100 should, in response to a lateral impact upon the rail
18, react in the same manner as the installation 10 described earlier. The weak posts 22
will yield or be deflected thereby softening the impact for the impacting vehicle. In an
end-on impact, the SRT end treatment 102 will result in axial collapse of the rail 18. The
rail 18 will be released from the weak support posts 22 as the connectors 56 are pulled
out of the rail 18.
A principal advantage is that guardrail installations constructed in accordance with the present invention are more forgiving during an impact to the lateral side thereby resulting in less damage to impacting vehicles and their passengers. Strong wooden support posts used in conventional systems do not easily yield in a collision and thus cause significant damage to the impacting vehicle. At the same time, the weak posts 20 used in the invention are capable of arresting an impacting vehicle that would impact the lateral side of the rail 18. This capability is provided, in part, by the brackets 50 and the anchorage afforded the system by the tension cable assembly 48. A further considerable advantage provided by the present invention is the savings in cost over installations that utilize more expensive strong wooden posts.

While the invention has been shown or described in only some of its forms, it should be apparent to those skilled in the art that it is not so limited, but is susceptible to other various changes without departing from the scope of the invention.
CLAIMS

What is claimed is:

1. A guardrail terminal comprising:
   a corrugated rail member having a longitudinal end;
   an unmodified weak support post supporting a portion of the rail member; and
   a safety device at its end.

2. The guardrail terminal of claim 1 further comprising a breakaway post proximate the end of the rail member, the breakaway post supporting the end of the rail member.

3. The guardrail terminal of claim 1 wherein the safety device comprises a GET.

4. The guardrail terminal of claim 1 wherein the safety device comprises an SRT.

5. The guardrail terminal of claim 1 wherein the unmodified weak support post comprises a C-120 metal post.

6. The guardrail terminal of claim 1 wherein the unmodified weak support post comprises a 4" diameter wood post.

7. The guardrail terminal of claim 1 wherein the unmodified weak support post comprises an S3 x 5.7 steel section post.

8. The guardrail terminal of claim 3 wherein the GET comprises an impact head having a reduced traffic side profile.

9. The guardrail terminal of claim 1 further comprising a bracket disposed between the unmodified weak support post.
10. A guardrail terminal comprising:
    a corrugated rail having a longitudinal end;
    a safety device at the longitudinal end;
    a breakaway support post supporting the longitudinal end of the rail, the
    breakaway support post being formed of metal; and
    an unmodified weak metal post supporting a central portion of the rail.

11. The guardrail terminal of claim 10 wherein the breakaway support post is formed
    of metal.

12. The guardrail terminal of claim 10 wherein the safety device comprises a GET
    impact head.

13. The guardrail terminal of claim 10 wherein the safety device comprises a slotted
    section within the rail.

14. The guardrail terminal of claim 10 wherein the weak metal support post
    comprises a C-120 style support member.

15. The guardrail terminal of claim 14 further comprising a U-shaped bracket
    disposed between the rail and the weak metal post.

16. An improvement to a guardrail terminal having a corrugated rail with a safety
    device, the improvement comprising:
    a plurality of unmodified weak support posts affixed to the rail and supporting the
    rail above the ground.

17. The improvement of claim 16 wherein the weak support posts are formed of
    metal.
18. The improvement of claim 17 further comprising a breakaway support post located proximate a longitudinal end of the rail.

19. The improvement of claim 18 wherein the breakaway support post is formed of metal.

20. The improvement of claim 17 wherein the weak support posts comprise C-120 style posts.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7. EDI15/14

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED:
Minimum documentation searched (classification system followed by classification symbols)
IPC 7 E01F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic database consulted during the International search (name of data base and, where practical, search terms used)
WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT.

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>US 4 928 928 A (THE TEXAS A&amp;M UNIVERSITY SYSTEM) 29 May 1990 (1990-05-29)</td>
<td>1-3, 6, 8</td>
</tr>
<tr>
<td>A</td>
<td>cited in the application page 6, line 8 -page 10, line 14; figures 1, 2</td>
<td>12</td>
</tr>
<tr>
<td>Y</td>
<td>US 5 765 811 A (ALBERSON ET AL.) 16 June 1998 (1998-06-16)</td>
<td>1-3, 6, 8</td>
</tr>
<tr>
<td>X</td>
<td>column 2, line 59 -column 3, line 17; figure 12</td>
<td>16, 18</td>
</tr>
<tr>
<td>X</td>
<td>cited in the application page 6, line 16 -page 8, line 33; figures 1, 2</td>
<td></td>
</tr>
</tbody>
</table>

[ ] Further documents are listed in the continuation of box C.  [X] Patient family members are listed in annex.

* Special categories of cited documents:
- *A* document defining the general state of the art which is not considered to be of particular relevance
- *E* earlier document published on or after the international filing date
- *G* document referred to in oral disclosure, use, exhibition or other means

** Special categories of cited documents:
- **F** later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- **X** document of particular relevance; the claimed invention cannot be considered to be of particular relevance (or a person skilled in the art)
- **Y** document of particular relevance; the claimed invention cannot be considered to be of particular relevance (or a person skilled in the art)

Date of the actual completion of the international search
5 February 2002

Date of mailing of the international search report
11/02/2002

Name and mailing address of the ISA
European Patent Office, P.O. 5018 Patentlaan 2
NL-2280 HU Rijswijk
Tel, 1-(31-70) 340-2040, Tx. 31 651 epo nl,
Fax, (131-70) 310-3016

Authorized officer
Mysliwetz, W

Form PCT/ISA/210 (second sheet) (July 1992)
<table>
<thead>
<tr>
<th>Patent document cited in search report</th>
<th>Publication date</th>
<th>Patent family member(s)</th>
<th>Publication date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>AU 2948089 A</td>
<td>11-08-1989</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CA 1306130 A1</td>
<td>11-08-1992</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DE 68914647 D1</td>
<td>19-05-1994</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DE 68914647 T2</td>
<td>28-07-1994</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DK 168090 A</td>
<td>11-09-1990</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NO 903108 A</td>
<td>11-09-1990</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WO 8906721 A1</td>
<td>27-07-1989</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US 5078366 A</td>
<td>07-01-1992</td>
</tr>
<tr>
<td>US 5765811 A</td>
<td>16-06-1998</td>
<td>NONE</td>
<td>NONE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WO 9429528 A1</td>
<td>22-12-1994</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US 5547309 A</td>
<td>20-08-1996</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US 5503495 A</td>
<td>02-04-1996</td>
</tr>
</tbody>
</table>