ET-Plus Terminal Impacts – Further Evaluation of Their In-Service Performance

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It was in the summer of 2014 that Gorski Consulting was made aware of certain concerns regarding the safe functioning of ET-Plus guardrail terminals manufactured by Trinity Highway Products of Dallas Texas. Through various news media, primarily in the U.S., we came to understand that there was the possibility that these terminals may be jamming when struck by a wayward vehicle. Instead of jamming they are supposed to allow the terminal to ride on the rail while the rail passes through a narrow channel "throat") causing the rail to be flattened out and coil. This rail deformation is supposed to be a major, if not the primary, way that the kinetic energy of impact is dissipated in controlled manner.

Upon hearing of these potential problems Gorski Consulting set out in the fall of 2014 to conduct surveys of the condition of such installations in south-western Ontario. The results of these surveys were presented in articles that were uploaded to the Articles page of the Gorski Consulting website. Subsequently Gorski Consulting has also begun examinations of ET-Plus terminals that were damaged from impacts and this information is also being posted on the Gorski Consulting website.

Generally, there has been an air of secrecy and misinformation provided by most official agencies such that a proper, independent evaluation of the performance of the ET-Plus is not available. Without the cooperation of authorities Gorski Consulting has taken the initiative to conduct investigations within the limits of our capabilities. Gorski Consulting has no way of examining the full evidence of the damaged terminals, the damaged vehicles and the injuries caused to those involved in the impacts. The best that can be done is to locate impacted terminals and document their damaged state.

In a previous Gorski Consulting article ("ET-Plus Terminal Impacts – Evaluation of Their In-Service Performance"), dated March 12, 2106, six instances of impacts of ET-Plus terminals were reported. The present article is a report on an additional 4 instances.

Incident #1: Eastbound Highway 401 West of Highbury Ave, London, Ontario

The present incident was documented on January 27, 2016. Figure 1 shows the impacted ET-Plus terminal located on the south side of the eastbound lanes of Highway 401, just west of the Highbury Avenue interchange in London, Ontario. Figure 2 shows how the guardrail has buckled and the terminal has rotated to a ninety degree angle.

Figure 1: View, looking east, at the damaged ET-Plus terminal located on the south side of the eastbound lanes of Highway 401 just west of Highbury Avenue.

Figure 2: View looking east at the ET-Plus terminal showing it has rotated to a ninety degree angle as the guardrail has buckled and prevented passage through the throat of the terminal.

Figure 2 also shows how the rail has buckled in the further distance behind the terminal demonstrating that the preponderance of energy was not being dissipated through the passage of the rail through the terminal but that a significant portion of the energy was being dissipated through deformation of the guardrail system distant from the terminal.

The argument may be put forth that the manner of energy dissipation is immaterial provided that the end result is a lessening of the collision consequences. While examining a damaged system Gorski Consulting has no ability to examine the damaged vehicle or what injuries might have occurred its occupants thus we may not be in a position to provide an opinion as to the proper functioning of the system. Yet, there is an obvious haphazard manner of substantial deformation accompanied by a relatively small length of rail that has passed through the throat of the terminal. Figures 4, 5 and 7 show the short length of rail that has been flattened and coiled as it has been squeezed through the narrow opening of the terminal's throat.

Figure 3: View showing how the ET-Plus terminal has rotated ninety degrees with respect to the length of the rail. Clearly, if any additional energy had to be dissipated it would not take place via the passage of the rail through the throat of the terminal.

Figure 4: View of the deformed end plate of the ET-Plus terminal and the short length of the rail that has passed through the throat of the ET-Plus terminal.

Figure 5: View of the ditch side of the terminal showing the short length of the rail that passed through the throat thus demonstrating the small amount of energy that was dissipated by this mechanism.

Figure 6: View showing the portion of the rail just behind the rear edge of the terminal. An obvious downward buckling of the rail exists at the rear of the terminal demonstrating that no additional length of rail would pass through the terminal.

Figure 7: View looking down at the short length of rail that has been squeezed through the throat of the terminal. The flattening and coiling of the rail as it is squeezed through the narrow throat of the terminal is the mechanism that is shown to dissipate a large portion of the kinetic energy in controlled, compliance tests. Yet, in this real-life example that mechanism is largely nonfunctional.

Figure 8: View showing how the terminal has rotated to a ninety degree angle with respect to the guardrail. Clearly no additional length of the rail could be expected to pass through the terminal.

Incident #2: West Side of Wonderland Road South, South of Glanworth Drive, London, Ontario

This incident was documented on March 25, 2017. The site is along a section of Wonderland Road that contains a hard-top surface that is poor condition. A southbound vehicle struck the ET-Plus terminal located at the north end of guardrail and bridge across a small creek just north of Orr Drive, just south-west of the limits of the City of London, Ontario.

Figures 9 through 13 show how the ET-Plus terminal has been rotated to a position almost perpendicular to the length of the guardrail. The rail is buckled at the rear edge of the terminal such that no additional length of the rail is capable of passing through the terminal's throat. These Figures also show that there is almost no additional buckling of the guardrail in the distance south of the terminal thus this is not a high severity impact.

Figure 14 shows a view looking at the length of the rail that has been squeezed through the throat of the terminal. The measurement method shown in Figures 15, 16 and 17 indicates that only 114 centimetres of the rail has passed through the terminal yet we observe that the terminal is already in an extreme state of rotation.

Figure 9: View looking south at the struck ET-Plus terminal on the west side of Wonderland Road.

Figure 10: View, looking north, showing the approach that the southbound striking vehicle would have had on impact with the terminal.

Figure 11: View, looking south, at the ET-Plus terminal which has been rotated allow to a ninety degree angle with respect to the length of the guardrail.

Figure 12: A view of the location at the back of the ET-Plus terminal where the guardrail has buckled thus not allowing any additional length to be squeezed through the throat of the terminal.

Figure 13: View, looking north, at the ET-Plus terminal which has been rotated almost ninety degrees preventing any further riding of the terminal along the rail and thus preventing any further energy dissipation by this mechanism.

Figure 14: View, looking down, at the short length of guardrail that has passed through the throat of the ET-Plus terminal.

Figure 15: View showing the method used to measure the length fo the guardrail that has passed through the throat of the terminal. Here the zero end of a tape measure is placed at the throat and the tape is then wrapped around the coil of the deformed rail as shown in Figure 16.

Figure 16: View of the measurement tape being wound around the contours of the deformed rail that has passed through the throat of the ET-Plus terminal.

Figure 17: View of the end result of the measurement method shown in Figures 15 and 16, indicating that 114 centimetres of the rail had been squeezed through the throat of the terminal.

Incident #3: East Side of Highway 28, Approximately 1 km North of Long Lake Road, Approximately 15 km North of Burleigh Falls, Ontario

This incident was documented on April 21, 2017. The site of this ET-Plus terminal is located in a remote part of Highway 28, adjacent to Kawartha Highlands Provincial Park, approximately 150 kilometres northeast of Toronto, Ontario.

This scenario demonstrates a common method by which the ET-Plus terminal fails to perform in the manner shown in its compliance testing. Figures 18 through 21 show that the principal deformation of this installation is the dramatic impact of the rear edge of the channel onto the top edge of the guardrail. Figure 22 shows that only a very short length of the leading edge of the rail has passed through the throat of the terminal. Once the deformed portion of the rail reaches that throat the rail is likely to become jammed in the throat preventing any further dissipation of energy via that mechanism. Thus this impact has caused a significant deformation to the top edge of the rail **before** the terminal and channel have had a chance to slide along the rail and dissipate any significant energy. If the system was struck with greater severity it is highly unlikely that any of the rail could pass through the narrow throat of the terminal and that mechanism of energy dissipation would be nullified. This failure is not an isolated event as a number of previous incidents have shown the same failure mechanism. Previous incidents have shown this deformation of the top edge of the rail at very low severities of impact.

Figure 18: View, looking north, at the impacted ET-Plus terminal located on Highway 28. Note that there is very little evidence of damage yet there a major buckling of the guardrail just at the back of the terminal channel.

Figure 19: View of the impacted terminal showing that the plate has been rotated upward while the rear of the channel has been rotated downward onto the top edge of the guardrail causing the significant deformation in the rail.

Figure 20: Ditch side view of the impacted terminal. This view illustrates the common manner in which the rear edge of the terminal channel impacts the top edge of the rail causing the rail's deformation.

Figure 21: View of the rear edge of the terminal channel and the extent of the deformation to the top of the guardrail. The deformation of the rail prevents it from passing through the throat of the terminal and thus jamming which prevents the energy from being dissipated in the manner that is demonstrated in the controlled compliance tests.

Figure 22: Close-up view of the throat of the terminal showing a very short portion of the leading edge of the rail beginning to be squeezed through the narrow throat. With the deformation of the top of the rail there is little hope that any additional length of rail will pass through this narrow opening and thus the designed method of energy dissipation has failed.

Incident #4: East Side of Highway 28, Approximately 1 km North of Long Lake Road, Approximately 15 km North of Burleigh Falls, Ontario

The present incident was documented on April 21, 2017. This site was located approximately 750 metres south of the site at Incident #3, or approximately 300 metres north of long Lake Road.

Figures 23 through 27 show how the terminal, channel and guardrail have all sustained major deformations yet there is only a small amount of rail that has managed to pass through the throat of the terminal. Thus a significant amount of energy was dissipated by the haphazard deformation of the system but not via the mechanism shown in the compliance testing. Obviously it cannot be known how the striking vehicle and its occupants fared in the event. However, if this incident resulted in benign injury consequences then it has to be concluded that the result would be by way of luck rather than by design. Such luck cannot be counted on in the overall scheme of preventing injury and death.

Figure 23: View, looking north at the damaged ET-Plus terminal on the east side of Highway 28.

Figure 24: View showing that the terminal plate has been rotated upwards.

Figure 25: View showing that only a small length of the rail has passed through the throat of the terminal.

Figure 26: This view shows how the channel has been greatly deformed along with the rail within it.

Figure 27: Top view showing that the guard rail is buckled within the channel.

Discussion

The results of these field examinations continue to produce concerns regarding the ET-Plus terminal's performance in real-life incidents. In all four instances presented in this article the terminal failed to ride along the rail as was demonstrated in the compliance tests.

In one of the instances (Incident #3:Highway 28) the impact was not as severe and a common problem was evident: that the rear edge of the terminal channel came down onto the top surface of the guardrail and deformed the rail before the rail reached the throat of the terminal. This is not an isolated incident but it has been documented by Gorski Consulting in previous incidents. This prior deformation of the rail could be one way in which the rail becomes jammed in the throat of the terminal thus preventing the terminal and channel from riding on the rail while also preventing the rail from being squeezed through the throat of the terminal as it is designed. This mechanism of failure is unlikely to be detected in higher severity impacts because of the magnitude of the resultant deformation which hides the progress of that failure.

Other researchers have claimed that the rail folds over itself to form a reinforced spear that can potentially penetrate an impacting vehicle. This result was demonstrated in the one of the re-tests of the ET-Plus at the South West Research Institute as shown in Figures 28 through 34.

In Figures 28 and 29 we see a small Geo Metro making initial contact with the terminal and then in Figure 30 we see that, after a substantial distance of travel a considerable length of the rail has been extruded through the terminal in a curled state.

Figures 31 through 34 show the results of the compliance test as the Geo Metro rotates and the rail begins to buckle. Here we see that the rail forms a spear that penetrates the driver's side door and enters into the driver's seating space. This is an obvious injury producing consequence whose consequences to a live driver in a real-life collision could be potentially fatal if the wrong set of factors is assembled.

The results of the Gorski Consulting field examinations have raised concerns regarding the manner in which the rear edge of the channel of the ET-Plus often makes a violent vertical impact with the top edge of the rail causing the top edge of the rail to become deformed before it enters the terminal. In the very narrow confines the throat of ET-Plus head, a deformed rail may not pass through it in the manner it was designed and the rail could jam within the terminal.

Gorski Consulting continues to express the opinion that, for the safety of the general public, it is essential that corrections be made regarding how road safety data is collected and analysed. Those experts who claim to be independent but have a vested interest in providing a biased analysis must be removed from the process. When an impact of a roadside structure occurs it must be properly documented and that information must be made available to the public so that the hiding of safety problems by persons and agencies that have a vested interest is minimized.

Figure 28: Example of the compliance test set-up taken from the South West Research Institute's (Texas) re-testing of the ET-Plus in early 2015.

Figure 29: View of Geo Metro making initial contact with the ET-Plus head.

Figure 30: View of the Metro after it has travelled a considerable distance and has caused a considerable amount of rail to be extruded through the terminal head.

Figure 31: The rail begins to buckle the Metro rotates.

Figure 32: The rail continues to buckle as the Metro continues to rotate.

Figure 33: The rail doubles over just behind the terminal forming a spear that penetrates into the driver's door.

Figure 34: As the Metro continues to rotate the rail forms a spear that penetrates the driver's interior.

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