Trinity Guardrail End Cap Survey - Part III

Posting Date: 21-Oct 2014

Certain guardrail end caps produced by Trinity Highway Products of Dallas Texas are alleged to be defective and dangerous. The truth of the allegations will be determined in a U.S. court case commencing in November, 2014. At the heart of the issue is a redesigned guardrail end cap or terminal, the ET-Plus.

The ET-Plus is made up of an end cap, terminal or head, and a channel that are attached to the end of a typical "W" rail of a roadside guardrail. When impacted by a wayward vehicle the end cap and channel are designed to ride on the "W" rail while allowing that rail to pass through the channel. The head is designed with a throat that causes the "W" rail to flatten out and deform into a ribbon. The rail is then redirected out the side of the head. This action absorbs the energy needed to bring the impacting vehicle to a controlled ride-down of the impact. It is alleged that the dimensions of the head and channel were altered by Trinity between 2000 and 2005 without informing the U.S. Federal Highway Safety Administration (FHWA). It was these dimensional changes that allegedly caused the rail to fail to pass through the channel and head and thus jam the system. The effect on impacting vehicles included inappropriate rollovers and instances of impaling of the vehicles by the rail.

It has been estimated that there could be as many as 500,000 installations of these units throughout the United States and it is likely that the product is similarly popular in Canada.

Given the large number of these units that are installed throughout North American highways Gorski Consulting has commenced a survey of roads and highways in Southern Ontario to document the locations of those units that resemble the described Trinity products and to provide photographic evidence of their present condition.

Our survey began with an article uploaded to the Articles page of the Gorski Consulting website entitled "Trinity Guardrail End Caps In & Near London Ontario - Survey of Locations & Condition" in which we documented the characteristics of 16 installations. In a second article ("Trinity Guardrail End Cap Survey - Part II") we reported on an examination of 6 additional end caps in the vicinity of Highway 401 in south London, Ontario.

The present article will review 10 end caps at three sites whose installations were found primarily north-east of London, Ontario, mostly along Highway 7.

To maintain some continuity we have decided to continue the numbering of the sites from the previous article.

Survey of Trinity End Caps

16. Highway 7 at Railway Bridge West of Cobble Hills Road, Middlesex & Perth Counties Border

End Cap at the West End of the South Guardrail.

Figure 1: View looking east on Highway 7 toward the west end cap on the south guardrail.

Figure 2: View of west end cap and hazard marker post at the south guardrail.

Figure 3: Street side view of guardrail, end cap and hazard marker post.

Figure 4: View of channel showing the difference in the horizontal angle compared to the "W" rail.

Figure 5: View of bottom of channel showing some gravel lying within it.

Figure 6: View looking through crevice in the bottom of the channel at a substantial amount of gravel that is lying on the bed of the channel.

Figure 7: View of standard width of 15 inches of the end plate.

Figure 8: The bottom of the end plate is about 5 inches above the ground.

Figure 9: Ditch side view of the end plate showing a substantial amount of gravel lying on the flat portions of the unit.

Figure 10: View of substantial amount of gravel lying at the throat of the channel where the flattened "W" rail is supposed to exit when the end is displaced by an impact.

Figure 11: View of typical, 4-inch-wide channel.

Figure 12: View of backside of "w" rail and channel showing gravel lying at the interface between the bottom edge of the rail and the channel.

Figure 13: Close-up view of typical stone from the gravel lying within the interface of the channel and rail.

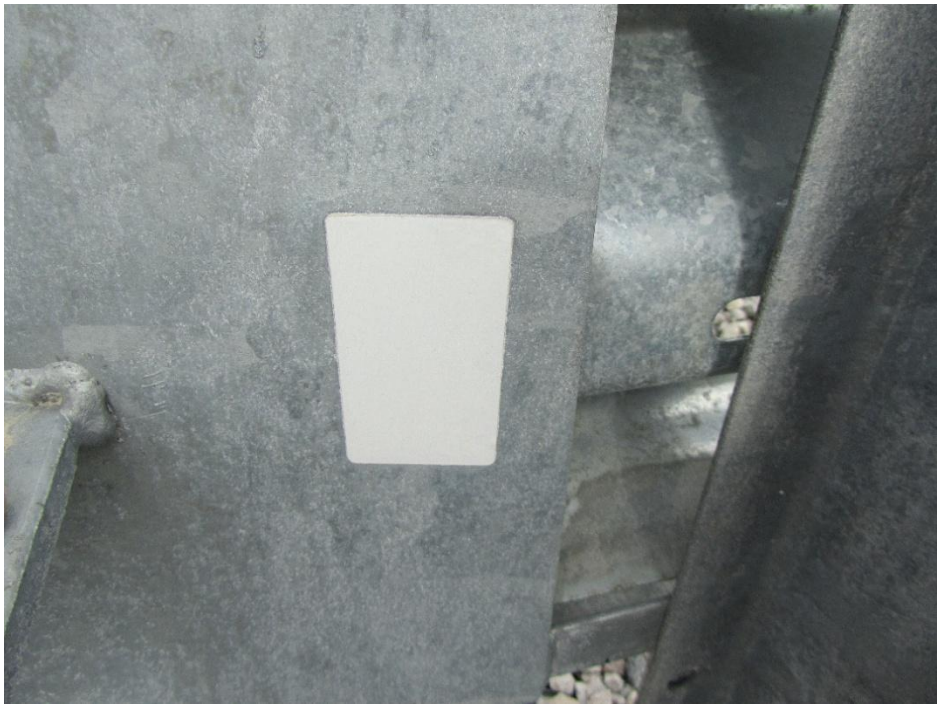

Figure 14: View of Trinity label whose writing has been weathered away but that is typically located on the end plate.

Figure 15: Close-up view, inside the throat of the channel showing the end of the "w" rail and the walls of the plate which are designed to flatten the rail as it passes through it. If gravel becomes jammed within this interface it could interfere with this motion of this system.

Figure 16: View of measurement being taken to document the position of the end cap with respect to the rail.

Figure 17: Result of measurement indicates a distance of 36.25 metres.

Figure 18: View of measurement taken to document the position of the hazard marker post in front of the end plate.

Figure 19: Result of measurement indicates that the hazard marker post is approximately 58.5 inches distance from the end plate.

Figure 20: View showing a measurement being taken of the height of the hazard marker post and its signage. The top of the diamond reflector is about 59.5 inches above the ground.

Figure 21: View showing that there is a substantial drop of the gravel surface on the ditch side of the end cap that could have an effect on the height at which as striking vehicle makes contact with the end plate.

Figure 22: View of the bottom anchorage of the vertical post just behind the end plate. There is a separation in the slip fit of the longitudinal bottom rail and this vertical post at the lower anchorage bolt.

End Cap at the West End of the North Guardrail

Figure 23: Street side view of north guardrail, end cap and post with hazard warning sign.

Figure 24: Street side view of end cap and post containing hazard warning sign.

Figure 25: View of gravel lying on the flat surface of the end cap just behind the end plate.

Figure 26: View of typical 15-inch-wide end plate.

Figure 27: The base of the end plate is 9 inches above the ground.

Figure 28: view of 4-inch-wide channel.

Figure 29: Ditch side view.

Figure 30: View of measurement to document position of end cap.

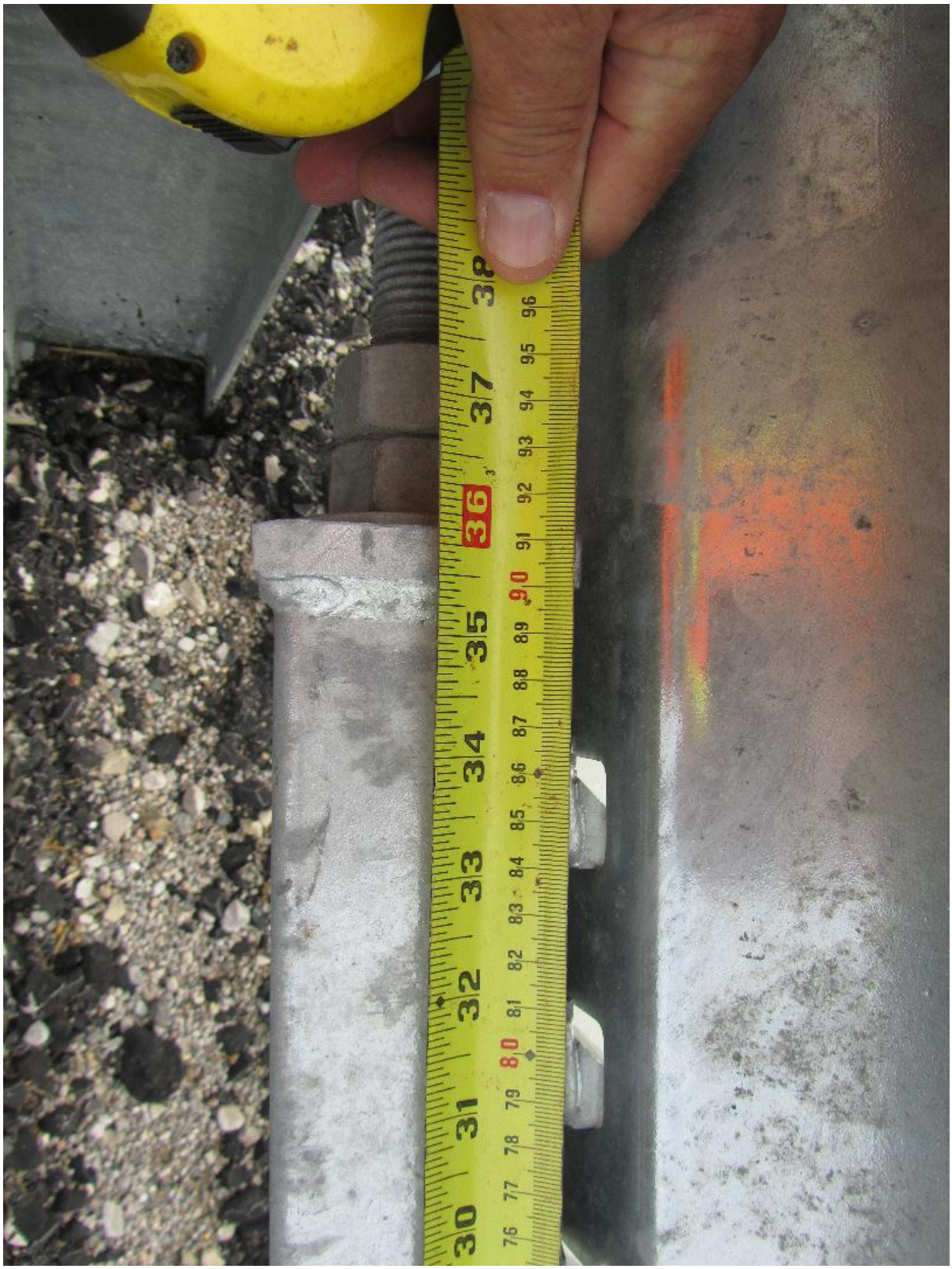

Figure 31: Result of measurement indicates 36 inches.

Figure 32: Measurement to document distance from end plate to hazard sign post.

Figure 33: Result of measurement indicates 56.5 inches.

Figure 34: Measurement indicates height of hazard sign is about 59 inches.

End Cap at the East End of the South Guardrail

Figure 35: Overall view, looking west, of the east end of the south guardrail.

Figure 36: Street side view of guardrail, end cap and post with hazard warning sign.

Figure 37: Street side view of end cap.

Figure 38: Close-up view of deposit of gravel resting in the horizontal recess behind the end plate

Figure 39: View of the bottom edge of the channel and rail showing the existence of gravel accumulated in the recess.

Figure 40: View of substantial amount of gravel lying in the bottom recess between the channel and bottom of the rail.

Figure 41: Close-up view if extensive amount of gravel lying in the recess of the channel along the bottom of the rail.

Figure 42: Measurement indicating the standard 15-inch-wide end plate.

Figure 43: Measurement indicating that the bottom edge of the end plate is about 9 inches above the ground.

Figure 44: Measurement indicating that the channel is 4 inches wide.

Figure 45: Ditch side view of end plate and channel.

Figure 46: View of standard measurement being taken to establish the position of the end cap.

Figure 47: Result of measurement indicates a distance of 36.25 inches.

Figure 48: Measurement being taken to determine the distance from the post of the hazard warning sign to the end plate.

Figure 49: Result of measurement indicates a distance of 64 inches.

Figure 50: View of measurement taken to establish the height of the hazard warning post and sign.

Figure 51: View indicating that the height of the hazard warning is about 58.5 inches.

End Cap at East End of North Guard Rail

Figure 52: Overall, street side view of end cap, guardrail and hazard warning sign.

Figure 53: Overall, street side view of end cap.

Figure 54: View of typical deposit of gravel on the horizontal landing just behind the end plate.

Figure 55: View of substantial deposit of gravel in the recess of the bottom of the rail and channel.

Figure 56: Close-up view of the substantial amount of gravel lying the recess between the bottom of the rail and channel.

Figure 57: Measurement indicating the standard 15-inch-wide end plate.

Figure 58: Measurement indicating that the bottom of the end plate is about 5.25 inches above the ground.

Figure 59: Overall, ditch side view of end cap.

Figure 60: Measurement confirming that this is a 4-inch-wide channel.

Figure 61: Ditch side view of end cap showing a white label attached to the vertical wall of the end plate throat.

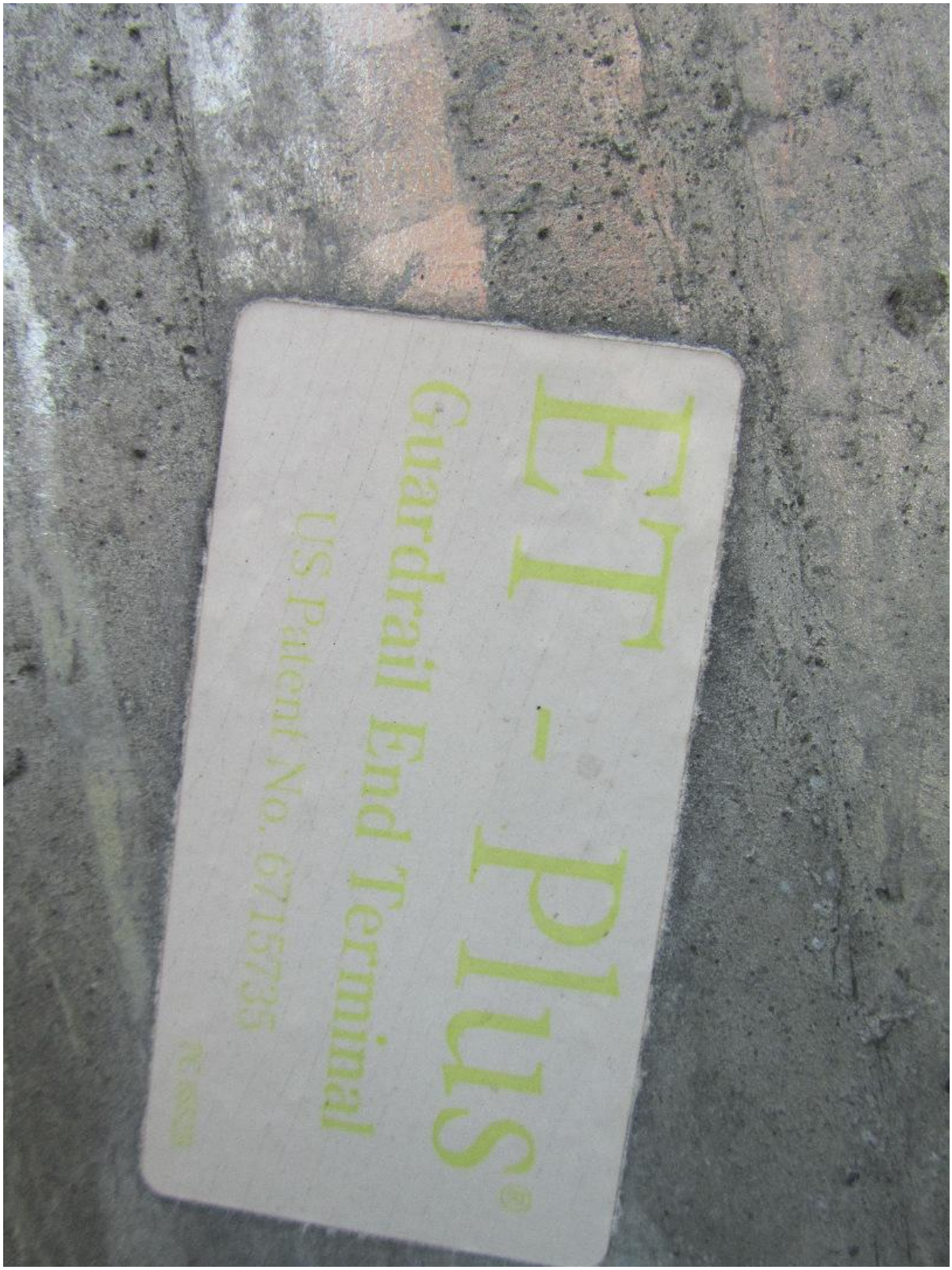

Figure 62: Close-up view of label indicating this is an ET-Plus unit.

Figure 63: View of patent number stamped to the top of the channel.

Figure 64: View of standard measurement being taken to establish the position of the end cap.

Figure 65: Result of measurement indicating a distance of 36.5 inches.

Figure 66: View showing the distance between the hazard warning sign and the end plate is about 62.5 inches.

Figure 67: Measurement showing that the height of the hazard marker is about 62 inches above the ground.

Figure 68: Overall view, looking west, of the north guardrail and hazard warning sign.

17. Highway 7 at Thames River Bridge, Middlesex & Perth Counties Border

End Cap at West End of South Guardrail

Figure 69: Overall view, looking east, of the hazard warning sign, end cap and guardrail.

Figure 70: Overall, street side view of end cap and guardrail.

Figure 71: View of difference in horizontal angle of the rail and the channel.

Figure 72: Overall, ditch side view of end cap.

Figure 73: Measurement confirming the 15-inch width of the end plate.

Figure 74: Measurement confirming 4-inch width of channel.

Figure 75: View of measurement being taken to establish the position of the end cap.

Figure 76: Result of measurement indicating a distance of 36 inches.

Figure 77: View of measurement indicating that the distance between the end plate and hazard warning sign is about 61 inches.

Figure 78: Measurement showing that the height of the hazard warning is about 56 inches.

End Cap at West End of North Guardrail

Figure 79: Overall, street view, of north guardrail, end cap and hazard warning sign.

Figure 80: Street side view of channel showing a substantial quantity of gravel lying in the recess between the bottom of the rail and channel.

Figure 81: Closer view of deposit of gravel lying the recess at the bottom of the rail and channel.

Figure 82: Close-up view of large quantity of gravel deposited in the recess at the bottom of the rail and channel.

Figure 83: Measurement confirming that the end plate is 15 inches wide.

Figure 84: Measurement indicating that the bottom edge of the end plate is about 10 inches above the ground.

Figure 85: Measurement confirming that the channel is 4 inches wide.

Figure 86: Additional view of gravel lying in the bottom of the channel near its rear edge.

Figure 87: Overall, ditch side view of end cap.

Figure 88: View of substantial quantity of gravel lying in the recess between the bottom of the rail and channel.

Figure 89: View of standard measurement being taken to determine the position of the end cap.

Figure 90: Result of standard measurement indicating about 36.5 inches.

Figure 91: Measurement indicates the distance between the end plate and hazard warning sign is about 55.5 inches.

Figure 92: Measurement indicating that the hazard warning is about 53.5 inches tall.

End Cap at East End of South Guardrail

Figure 93: Overall view, looking west, toward the east end cap on the south guardrail east of the Thames River Bridge.

Figure 94: Street side view of hazard warning sign, end cap and south guardrail.

Figure 95: Street side view of end cap showing substantial difference in the horizontal angle between the channel and the rail.

Figure 96: View of gravel and sand lying in the recess between the bottom of the rail and channel.

Figure 97: Measurement demonstrating the 15 inch width of the end plate.

Figure 98: Measurement indicating that the bottom of the end plate is about 5.5 inches above the ground.

Figure 99: Measurement confirming 4-inch width of channel.

Figure 100: Ditch side view of end cap.

Figure 101: View of gravel and sand lying the horizontal surfaces of the ditch side of the end cap.

Figure 102: View of measurement being taken to determine position of the end cap.

Figure 103: Result of measurement indicates a distance of about 37 inches.

Figure 104: View of measurement being taken to determine distance between end plate and hazard sign.

Figure 105: Result of measurement indicates 56 inches.

Figure 106: Measurement indicating height of hazard marker is about 60 inches.

18. Highway 7 Just West of Perth Road 120, Border of Middlesex and Perth Counties

End Cap at West End of South Guardrail

Figure 107: Overall view of west end cap and hazard sign at south guardrail.

Figure 108: Overall, street side view of hazard sign, end cap and south guardrail.

Figure 109: View of a few stones lying within the recess at the bottom of the rail and channel.

Figure 110: Close-up view of stones lying within the recess at the bottom of the rail and channel.

Figure 111: Measurement confirming 15-inch width of end plate.

Figure 112: Measurement indicating that the base of the end plate is about 6.5 inches above the ground.

Figure 113: Ditch side view of end cap showing the substantial difference in the horizontal angle of the rail and channel.

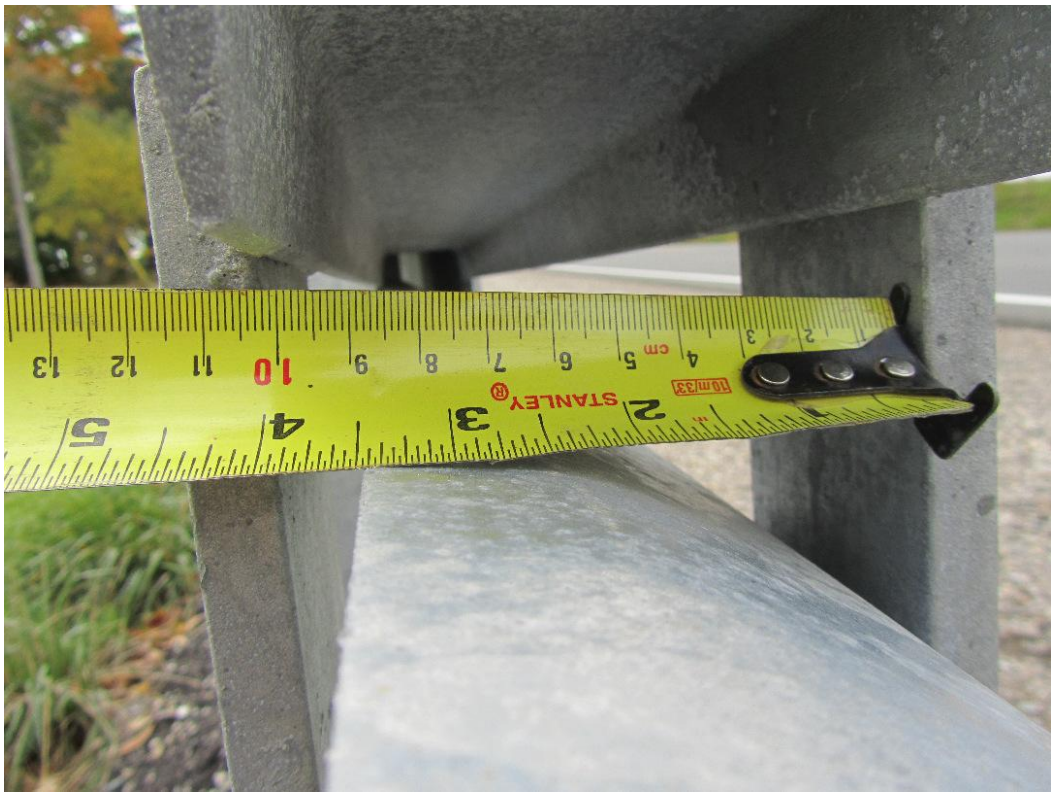

Figure 114: Measurement confirming 4-inch width of channel.

Figure 115: Additional evidence of gravel lying on the backside of the recess of the bottom of the rail and channel.

Figure 116: View of measurement being taken to document the position of the end cap.

Figure 117: Result of measurement indicates a distance of about 35.75 inches.

Figure 118: View of measurement indicating that the distance between the end plate and hazard warning sign is about 59.5 inches.

Figure 119: View of measurement indicating that the height of the hazard warning marker is about 59.5 inches.

End Cap at West End of North Guardrail

Figure 120: Overall view, looking north, at the hazard warning sign, end cap and north guardrail.

Figure 121: Street side view of west end cap.

Figure 122: View of gravel lying on the horizontal plate just behind the end plate.

Figure 123: View of large quantity of gravel lying in the crevice between the bottom of the rail and channel.

Figure 124: Street side view, looking toward the end plate, showing the large quantity of gravel lying within the crevice at the bottom of the rail and channel.

Figure 125: Measurement confirming the 4-inch width of the end plate.

Figure 126: Measurement indicating that the base of the end plate is about 9 inches above the ground.

Figure 127: Measurement confirming the 4-inch wide channel.

Figure 128: Ditch side view of end cap.

Figure 129: View of Trinity Highway Products label attached to the vertical wall behind the end plate.

Figure 130: Close-up view of Trinity Highway Products label.

Figure 131: Additional view of gravel lying on the backside of the crevice of the bottom of the rail and channel.

Figure 132: Eastward view showing channels dug in the gravel in front of the hazard warning sign likely caused by off-roading vehicles.

Figure 133: View looking north, showing the deep channels dug in the gravel shoulder likely by continual travel of off -road vehicles.

Figure 134: Result of measurement of the position of the end cap indicates a distance of about 37.5 inches.

Figure 135: Measurement indicating that the distance between the hazard sign and end cap is about 61 inches.

Figure 136: Measurement indicating the height of the hazard marker is about 59.5 inches.

End Cap at East End of South Guardrail

Figure 137: Overall view, looking west, at the hazard marker, end cap and south guardrail.

Figure 138: Street side view of hazard sign, end cap and south guardrail.

Figure 139: Street side view of end cap.

Figure 140: View of gravel lying on the horizontal plate just behind the end plate.

Figure 141: View of large quantity of gravel lying within the crevice between the bottom of the rail and channel.

Figure 142: Measurement confirming the 15-inch-wide end plate.

Figure 143: Measurement indicating that the base of the end plate is about 9 inches above the ground.

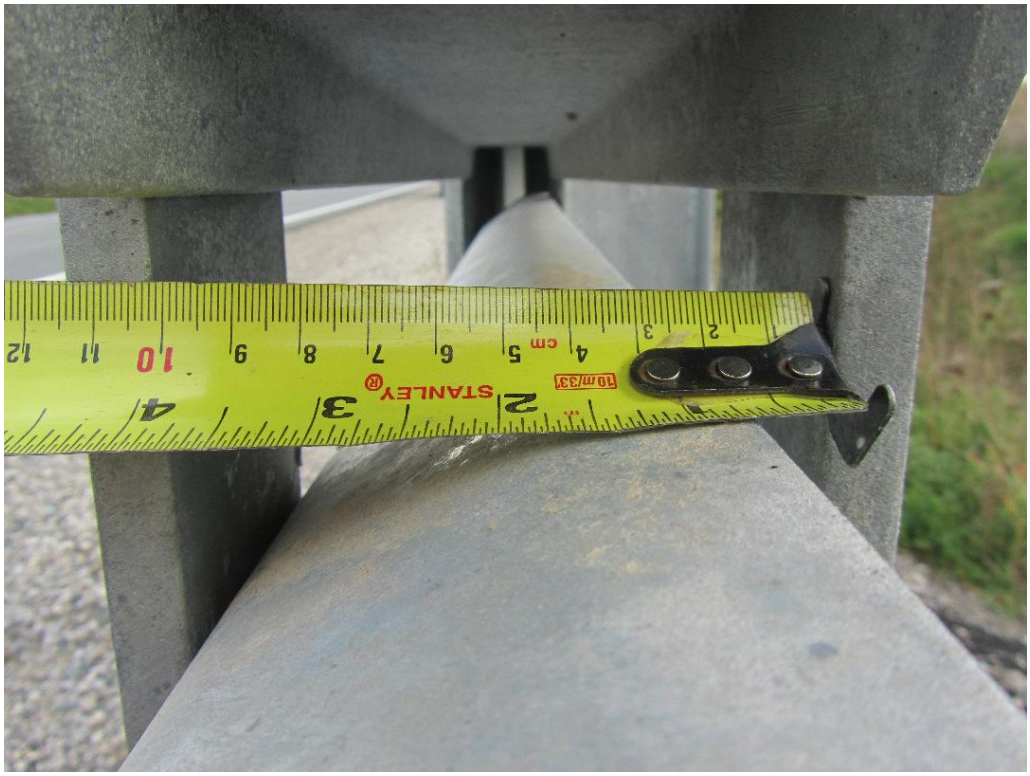

Figure 144: Measurement indicating that the channel is 4 inches wide.

Figure 145: Ditch side view of the end cap.

Figure 146: View of measurement being taken to document the position of the end cap.

Figure 147: Result of measurement indicating a distance of about 36 inches.

Figure 148: Measurement indicating the distance between the end plate and hazard sign is about 58.5 inches.

Discussion of Survey Findings

Three sites were examined in this latest survey of guardrail end caps exhibiting the characteristics of the ET-Plus system designed by Trinity Highway Products. These sites contained 10 end caps all of which exhibited the characteristics of the Trinity ET-Plus system.

The unusual finding about this set of end caps is that 8 of the 10 units contained contaminants of gravel within the crevice between the bottom of the rail and channel. This finding would appear to be significant as it is vital that the end cap ride in an unobstructed manner along the rail when it is displaced by the impact of a wayward vehicle. It is this motion of the end cap that allows the rail to pass through the narrowing throat, flattening out the rail and then bailing the rail out the side of the end cap. From our understanding, the basis of the defect allegations against the ET-Plus system is that modifications that narrowed the dimensions of its channel caused the rail to become jammed and the rail would not pass through the end cap as it was designed. If extraneous materials such as gravel are placed in the channel where the unobstructed motion is critical, such jamming of that motion would seem likely. It would seem that, aside from any other potential defects, the design of the ET-Plus system with its open channel, can cause foreign objects to enter into the channel and obstruct the motion of the system, thus making it fail.

While we have no specific knowledge of how so much gravel could become lodged within the channels of these end caps, we surmise that this could be related to snow plowing activities. Highway 7 in this region is known for its snow squalls that spill off of Lake Huron and thus larger quantities of snowfall are experienced. At the same time, snow plows along this rural highway are known to travel at substantial speed. Thus, while throwing the accumulated snow off the road surface, the plows also pick-up the gravel that is adjacent to the paved surface and this gravel is thrown against the nearby guardrails. As the end caps are also rained upon by this mixture of snow and gravel the material becomes deposited into the open crevice of the bottom of the channel. As the snow melts the gravel remains behind and thus we eventually see this deposit of gravel. Whether this is what actually happens remains to be determined as further study is needed.

After examining a total of 32 end caps we have begun to recognize a pattern where many of the channels are at a substantially different horizontal angle as compared to the rail that fits inside. We might consider that the instructions for the installation of the system could require that difference in angle, however it remains questionable what purpose that would achieve. The alternative hypothesis is that the weight of the end plate and channel might cause this unit to pivot downward and thus raising the rear edge of the channel. Again, at this early stage of our evaluations, we cannot be certain which hypothesis is true, or what other issues may be at play.

We have also observed that, at several installations, the ground on the ditch side of the end cap and guardrail is at a steep angle, often toward a deep ditch. This condition

would appear to be substantially different than the conditions under which the system is tested for compliance.

Furthermore, as experts in the reconstruction of real-world, loss-of-control events it is obvious to us that the compliance testing of the end caps in not realistic in providing an indication of how the system would function in a real-life incident. The obvious short-coming that we recognize is that, from our experience, a majority of vehicles that will strike an end cap will not do so with the front end of the vehicle in the manner that the system is tested for compliance. Historically, the majority of incidents where a vehicle might strike such an end cap would be where the vehicle enters into a state of rotation about its vertical axis, or yaw. The preponderant motion that develops is that the side of the vehicle would be expected to come into contact with the end plate, not the front end. Therefore it is unclear to us why this unrealistic compliance test was selected.

Our next survey article will discuss installations that were also examined in rural setting to the northeast of London, Ontario in the counties of Middlesex, Perth and Oxford.

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