Supplementary Notes
This is an interim report documenting the circumstantial evidence which has been collected after one winter cycle of in-service evaluation.

Abstract

Wooden guardrail posts are subject to splitting and rot as they age. It is common practice to replace these posts every 15 years.

In the early 1990's, the Minister (the Honourable Al "Boomer" Adair) made a commitment to purchase 3,500 recycled plastic guardrail posts for evaluation purposes. Due to manufacturing problems only a limited number of posts were installed on Hwy. 16:08 near Nojack.

In 1999, Amity acquired the technology and Alberta Research Council has been assisting Amity in improving the manufacturing process.

Arrangements were made to purchase 400 posts and install them in high-risk locations for in-service evaluations for use in the standard flexible, longitudinal roadside (weak post) barrier.

Based on observations to date and lack of official collision reports it appears that the weak posts system using recycled plastic posts is performing satisfactorily.

Considering that the recycled plastic post has several additional advantages that include longer service life, is reusable and recyclable, it is recommended that they be adopted as the Department standard post for a flexible longitudinal roadside barrier.

Key Words
Recycled plastic
Guardrail
Weak post
Traffic barrier systems

Distribution
Unlimited

Project Co-ordinator
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1.0 INTRODUCTION

Wooden guardrail posts are subject to splitting and rot as they age. It is common practice to replace these posts every 15 years. Wooden guardrail posts that have been in service between 8 and 15 years are evaluated and scheduled for replacement based on their condition and estimated remaining service life.

There is an estimated 300,000 wood posts in the primary highway system. Approximately 20,000 posts are replaced each year with ½ the replacements due to collision damage. Using a conservative service life of 30 years for recycled plastic posts the undamaged plastic posts will be reused during subsequent replacement and will provide a potential savings of about $250,000 (10,000*$25) annually in materials costs after the first 15 year replacement cycle.

2.0 OBJECTIVE

The objective of this project is:

Determine if recycled guardrail posts should be accepted for use in the department’s standard W-Beam (Weak Post) Unblocked Wood Post, Flexible, Longitudinal Roadside Barrier System.

3.0 BACKGROUND

Presently, the department uses the W-Beam (Weak Post) Unblocked Wood Post, Flexible, Longitudinal Roadside Barrier as the standard traffic barrier system. This barrier system consists of W-beam steel rails and treated wood posts at 3.8 metre spacing. The top of the rail is mounted at 695 mm above the pavement surface (centre bolt 540 mm above pavement surface). The primary function of the post, in this system, is to hold the barrier rail at the proper height when impacted by a vehicle. The W-beam guardrail acts as a tension ribbon and redirects the impacting vehicle when the rail is fully deflected. For this reason, installation at a given location is usually based on the ability to match the guardrail system’s deflection properties (2.5 m) with the space behind the guardrail to safeguard a vehicle from hitting the hazard during a collision with the rail.
W-Beam (Weak Post) System

Impact Performance: (Wood)

In crash tests the weak post system has successfully redirected vehicles in the 800-1800 kg range. Dynamic lateral deflection in the 1800 kg test (28°, 95 km/h) was 2.2 m. This barrier has not been tested with a 2000-kg vehicle, although field performance has not indicated a problem relative to this vehicle size. In a test to establish upper performance limits, this barrier failed to keep a 2100 kg van upright following a 95 km/h, 24° impact.

This system as with all barriers having relative narrow restraining width, is somewhat vulnerable to vaulting or vehicle under ride caused by incorrect mounting height or irregularities in the approach terrain.

References: TEB Traffic Control Standards
            AASHTO Roadside Design Guide

Recycled Plastic Guardrail Posts

Amity (of Clyde, Alberta) and Alberta Research Council (ARC) have joined forces to manufacture recycled plastic posts and have recently approached the department for acceptance as an alternative to wood posts.

Amity acquired the ELSRO technology and ARC has been assisting Amity in improving the manufacturing process. The process incorporates 31 kilograms of a 50/50 blend of cleaned and shredded plastic oil and herbicide containers with strips of fibre reinforcement inserted between the compacted layers. Metal forms containing the recycled plastic are heated to melt the plastic and placed in a press to form the desired shape and dimensions. The form is then immersed in a water bath to cool at a uniform rate in order to prevent non-uniform cooling which results in warping. The recycled plastic post is removed from the form and finished to accommodate the guardrail and bolt.

In the early 1990’s, the Minister (the Honorable Al “Boomer” Adair) made a commitment to purchase 3,500 recycled guardrail posts from ELSRO Construction products for evaluation purposes.

Due to manufacturing problems, the order was cancelled and ELSRO only delivered a limited number of posts. Those posts were installed in 1992 on Hwy. 16:08 near Nojack. Details are available in Report No. ABTR/RD/TM-92/09.

To-date two collisions have occurred at this site. In the opinion of the district staff, this system using the plastic posts, has performed as well as the standard wood post system.
Based upon the previous research, the department accepted the use of the recycled plastic guardrail posts for use on low risk locations and other non-safety-related applications as intended in the 1993 ministerial commitment.

**Report ABTR/RD/TM-92/09**

Two hundred and sixty metres of guardrail using the I-beam shaped recycled plastic posts manufactured by ELSRO were installed September 9, 1992 on Hwy. 16:08 (Edson district).

Handling and installation of this safety system was the same as the conventional wood post system. The colour of the post can vary depending on the source of the plastic. The cost in 1992 for a plastic post (6" x 8" x 5') was $15.00 compared to $14.25 for wood (1992 prices).

The report recommended that long term performance needs to be evaluated, over seasonal heat/frost cycles to determine if material will creep or become brittle due to extreme temperature or other environmental conditions (e.g. ultraviolet rays). It was also noted that the crash worthiness of plastic guardrail post must be examined and evaluated.

The report concluded that plastic guardrail posts can be installed at selective low risk locations or other non-safety related applications.

The manufacturer will be responsible for developing the general specification and quality control testing program for Alberta Infrastructure review. The manufacturer should also be encouraged to obtain certification for this system for full acceptance for a semi-rigid system.

### 4.0 ARC RESULTS:

**PHYSICAL PROPERTY MEASUREMENTS OF PLASTIC VERSUS WOOD GUARDRAIL POSTS**

The wood posts show that they require a greater load giving them a greater maximum stress at failure but they also bend considerable less before they fail. The plastic posts do not require as much load to cause failure but they bend considerable more before break, which means they require a greater strain at break.

The Amity plastic post formulation of 50/50 oil jugs to chemical jugs showed that at ambient temperatures and at – 30ºC the posts absorbed at least as much energy as the wood posts.
<table>
<thead>
<tr>
<th>Post Type and Test Condition</th>
<th>Maximum Stress (MPa)</th>
<th>Modulus of Elasticity (Mpa)</th>
<th>Energy Under the Curve (Joules)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood @ Ambient</td>
<td>30.6</td>
<td>1930</td>
<td>1660</td>
</tr>
<tr>
<td>Wood @ 40ºC</td>
<td>29.7**</td>
<td>2150</td>
<td>1600**</td>
</tr>
<tr>
<td>Wood @ -30ºC</td>
<td>21.1**</td>
<td>2770</td>
<td>650**</td>
</tr>
<tr>
<td>50/50 @ Ambient</td>
<td>9.6</td>
<td>200</td>
<td>1810</td>
</tr>
<tr>
<td>50/50 @ 40ºC</td>
<td>7.2</td>
<td>120</td>
<td>1550***</td>
</tr>
<tr>
<td>50/50 @ -30ºC</td>
<td>19.9</td>
<td>690</td>
<td>1670</td>
</tr>
</tbody>
</table>

** not taken to rupture
*** exceeded the limits of test without rupturing

5.0 IN-SERVICE BARRIER PERFORMANCE EVALUATION

Recycled plastic posts are an acceptable alternative to wooden posts in low risk locations. An implementation and in-service evaluation is required to determine if these posts would be acceptable in high-risk (collision prone) locations.

Arrangements were made to purchase 400 recycled posts and install them in high-risk locations for in-service evaluations for use in the standard weak post guardrail (flexible) system. The Operations Managers (OMs) selected test sites and a detailed evaluation process was developed to assess the performance at high-risk locations for full acceptance as an alternative to the standard wood post system.

In-service evaluation is the final and key step in determining how a safety feature performs during a broad range of collisions, environmental and operational situations for typical site and traffic conditions. The recommended safety performance evaluation factors for safety features are structural adequacy, occupant risk and post-impact vehicular response.

Collisions are random and extremely complex in nature and it is not feasible to collect sufficient data to develop statistically valid findings.

The goal of the in-service evaluation is to monitor several sites under “real world” conditions with the following objectives:

1. Demonstrate performance under a broad range of collisions. The data to be collected would include information on occupant injuries and vehicular impact condition of “reported collisions”. It is also desirable to measure the number of brush hits and drive away collisions in order to establish failure/success ratio and collision damage repair costs.
2. Identify factors that may compromise or defeat the performance.

3. Determine effects, if any, of extremes in heat and cold, ice, snow, rain, wind, etc. on collision performance and maintenance of the barrier.

4. Identify problems encountered during routine maintenance and damage repair.

It should be noted that longitudinal barriers generally fail due to structural inadequacies that allow snagging or pocketing on stiff points in the barrier system or rupture of the “weak points” such as a connection point.

This study is not to confirm or reject the acceptability of the flexible system as an alternative to the semi-rigid system but to determine if the recycled plastic post will perform in the same manner as the wood post in a flexible system.

**Site Locations:**

1. **North Central (Inland)**
   Highway 16:08, WBL @ Km 29.89, (Nojack), September, 1992.

   **Collision # 1.1 (April 11, 1994)**

   The collision involved a Tanker rollover (double trailer). Thirty to forty posts were removed and replaced. ARC conducted a failure analysis on the posts and concluded that they performed as well as expected and failed in a similar manner as a wood post system.

   Property damage caused by this collision was about $125,000. The majority of the posts were pulled out of the ground through yielding soil and failure occurred at the steel sections.

   **Collision # 1.2 (April, 2000) (Photos, Appendix A.1)**

   It is believed that the vehicle involved was a pickup truck. Approximately 50 metres of guardrail were damaged and 7 of the 14 posts were broken at the bolt holes. The guardrail was struck in three places with a 2-metre tear in the rail. There is no evidence of skid marks or debris from the vehicle at the site.

   The evidence indicates that the vehicle must have ridden on top of the rail in order to cause the damage to the rail and shear the tops off the posts.

   The rail had deflected about 1.0 metres, which is well within the maximum allowable deflection of for a flexible system of 2.5 metres.
The system exceeded the performance criteria for a flexible roadside barrier system.

No collision report or detailed in-service evaluation was received for this collision.

**Collision # 1.3 (May, 2000) (Photos, Appendix A.1)**

It was observed that two rail sections (one plastic and one wood) were involved in drive away collisions.

Both sections exhibit similar damage and performance.

*NOTE:* (Photos, Appendix A.1)

A snowplough had damaged two wooden posts. Similar marks were observed on the plastic posts but rather than shearing the post the damage was limited to a gouge in the base of the post.

2. **North Central (Inland)**
   Sherwood Park Freeway (1999), EBL Between 17th and 34th Street, East of Railway Overpass, South Side (60 posts on Tangent)

**Collision # 2.1 (October 1 or 2, 1999) (Photos, Appendix A.2)**

The type of vehicle involved in this collision is unknown and no collision report was filed. The ambient air temperature was about –4ºC when the collision occurred involving four sections of guardrail. Four posts required re-alignment due to soil yield and one section of rail (which was in direct contact with the vehicle) required replacement. The rail deflected about 25 cm with no problems or abnormal failure noted. The overall performance rating for this barrier system was good.

The In-Service Barrier Performance Evaluation Sheet and photos are provided in Appendix B.

3. **Peace Country (LaPrairie)**
   Hwy 2:62, West Hill, km 0.795 OR, 153 metres, 45 posts and km 0.795 OL, 219 metres, 65 posts.

**Collision # 3.1 (January 15, 2000) (Photos, Appendix A.3)**

The ambient air temperature was –35ºC and the collision occurred at the West end of the bridge structure with the guardrail attached to the bridge using the standard bridge guardrail end section.
Twelve (12) posts sheared off at ground level (replaced Jan. 19, 2000). It is assumed the vehicle involved was a pickup truck, which was westbound proceeding up the west hill. Apparently, the driver lost control and crossed the concrete median struck the guardrail then drove away.

Field Comments:

1. Extensive damage occurred to the plastic guardrail posts. It appears the plastic posts simply shear off when high impact collision occur.

2. Recycled plastic posts are not as effective as wood posts under extreme cold temperatures.

No collision report or detailed in-service evaluation was received for this collision.

3. **North Central (Pine West)**
   **Hwy 55:18 @ km 9.088 OR (45 posts)**

   Installed (Fall, 2000) (Photos, Appendix A.4)

   It was noted during installation that several of the posts were warped. They were usable but it was recommended that the Supplier offer a return policy for unacceptable posts.

   There are no collisions or in-service evaluations to report.

4. **Southern (Carmacks)**
   **Hwy 22:08 @ km 28.815 (45 posts)**

   This site is northbound and is situated on the down slope of a hill and on the inside of a curve. The existing rail will get hit four or five times annually. Commonly it will be large traffic that hits the rail in this area.

   There are no collisions or in-service evaluations to report.

5. **Southern (Carmacks)**
   **Hwy 8:06 @ km 15.710 (55 posts)**

   This site is eastbound on the outside of a curve and is attached to a bridge (Twin Bridge). Traditionally this section will be hit five to six times annually. It is usually by small passenger vehicles.

   The only comments received from the Contractor was that the posts are slippery to haul to the site but not any more difficult to install.
There are no collisions or in-service evaluations to report.

6. **Central (TSM)**
   **East Overpass at Vegreville (85 posts)**

   Installed October 08, 1999.

   There are no collisions or in-service evaluations to report.

7. **Other Sites**
   **7a. Hwy 2, Okotoks Interchange (Fall, 1999)**

   Two posts were broken off and several others were pushed over but were not broken. The guardrail was flexed outward.

   **7b. SH 794 Approximately 3 km North of Hwy 16.**

   Posts were sheared off and the rail flexed outwards.

   There are no collisions or in-service evaluations to report for either site. In both cases the evaluator stated that in his opinion the posts worked as well or better than wooden posts.

### 6.0 DISCUSSION OF RESULTS

In all cases:

- there were no “reported collisions” and there is no data available to determine occupant injuries or vehicular impact condition.

- the rail did not exceed the maximum allowable dynamic lateral deflection of 2.5 metres.

- the impact performance successfully redirected vehicles larger than those in 800-1800 kg range for which the weak post system is certified.

- the system did not exhibit any signs of structural inadequacies that allowed snagging or pocketing on stiff points in the barrier system or rupture of the “weak points” such as connection points.
The amount of damage to the recycled plastic posts is expected to be higher during extremely cold temperatures. The post yield forces are controlled by either post strength or soil confinement. In frozen soil the yield force is governed by the post strength only. In extreme cold temperatures the plastic posts were sheared off at ground level thereby transferring more of the impact energy through the rail to the adjacent posts. The wood posts typically fail by splintering and would absorb more of the impact energy before transferring it through the rail to the adjacent posts. This would result in less wooden posts being damaged at extremely cold temperatures. However, the plastic post will incur less damage than wood posts at higher temperatures as the failure should occur due to soil yield as was demonstrated in the Sherwood Park collision where all posts were salvaged and reused.

NCHRP 350 testing protocols for AASHTO certification is carried out under controlled conditions and does not account for extremes in temperature or variations in soil confinement.

The plastic posts appear to be more resistant to damage caused by routine maintenance activities. The brush hits from snowploughs and grass/weed cutting will gouge the surface of the post. Similar damage will splinter or damage the treated surface of a wooden post allowing moisture to enter and eventually rot to occur.

7.0 BENEFITS:

The use of recycled plastic posts is cost beneficial based on a life cycle analysis. Using a conservative estimate of double the life of a wooden post the recycled plastic posts will provide a significant savings based on a 15-year replacement cycle. The typical service life for other plastic products such as culverts, fence post etceteras is 50 to 100 years.

8.0 CONCLUSIONS AND RECOMMENDATIONS

Collisions are random events and extremely complex to analyze as evidenced by the lack of collisions in locations where more were expected and the number of collisions that happened in less likely locations.

Based on safety performance evaluation factors it can be concluded that the weak post systems using recycled plastic posts were structurally adequate with minimal occupant risk and minimal vehicular impact damage.

The performance of the system located on Hwy 16 (1992) shows no sign of environmental damage and in some respects appear to perform better against damage resulting from normal maintenance activities.
The overall consensus is that the recycled plastic posts performed as well or better than wooden posts. Considering that the recycled plastic post has several additional advantages including a longer service life, as well as being reusable and recyclable, it is recommend that they be adopted as the Department standard for a flexible longitudinal roadside barrier.
APPENDIX A
Location 1
North Central (Inland)
Hwy. 16:08 km 29.89 (Nojack)
Collision # 1.2

Overall view of collision site (looking west)
Sheared off recycled plastic post showing reinforced fabric
Damage to flex beam (tear)
Location 1
North Central (Inland)
Hwy. 16:08 @ km 29.89 (Nojack)
Collision # 1.2

Tear in flex beam.

Defect in wood post.

Bolt yielding through flex beam, post sheared.
Location 1
North Central (Inland)
Hwy. 16:08 @ km 29.89 (Nojack)
Collision # 1.3 (Brush Hits)

Brush Hits on Wood Post Sections

Brush Hits on Recycled Plastic Section
Location 1
North Central (Inland)
Hwy. 16:08 @ km 29.89 (Nojack)
Snowplough Damage
Wood versus Plastic
Location 2
North Central (Inland)
Sherwood Park Freeway (EBL)
Collision # 2.1

View of Collision (looking west)
Location 2
North Central (Inland)
Sherwood Park Freeway (EBL)
Collision # 2.1

View of Collision (looking East)
Location 2
North Central (Inland)
Sherwood Park Freeway (EBL)
Collision # 2.1

Detailed view of soil yield.
Location 3
Peace Country (LaPrairie)
Hwy. 2:62 @ km 0.795 OR and km 0.795 OL
Collision # 3.1
APPENDIX B
In-Service Barrier Performance Evaluation Sheet

1) Construction (weak-post system):  yes  no
   a) Is railing set to the correct height?  ☐  ☐
   b) Are posts at correct depth and inserted vertically?  ☐  ☐
   c) Are correct bolts and washers used for affixing railing?  ☐  ☐
   d) Are anchors placed solidly into ground?  ☐  ☐
   e) Is soil around posts compacted properly and flush to surface?  ☐  ☐

2) In-Service Maintenance (periodic checks required):  yes  no
   a) Any deformation noted in railing due to heat or cold?  ☐  ☐
   b) Any minor rubs or unreported hits noted (include plow blade hits)?  ☐  ☐
   c) Any deformations noted from minor rubs or hits?  ☐  ☐
   d) Any maintenance required? (Provide details below)  ☐  ☐

3) Crash Investigation:  yes  no
   a) Did vehicle penetrate barrier?  ☐  ☒
   b) Did vehicle vault over or under-ride barrier?  ☐  ☒
   c) Was the vehicle redirected back onto the road?  ☒  ☐
   d) Did rail anchor remain intact?  ☒  ☐
   e) Date and time of crash, if known?  October 1 or 2
   f) Type and model of vehicle involved in crash?  Unknown
   g) Any skid marks indicating the approximate angle of approach?  Yes
   h) Ambient temperature at the time the collision occurred?  -4°C
   i) Length of rail which was in direct contact with vehicle?  3.8 metres
   j) Overall length of rail needing replacement?  3.8 metres
   k) Number of plastic posts damaged?  None
   l) How many plastic posts sheared?  None
   m) Number of plastic posts pulled from the ground?  None
   n) Number of posts remaining intact but are deformed?  4 leaning
   o) Number of posts detached from railing?  None
   p) Maximum off-set of rail deflection from initial position?  25 cm
   q) Any problems or abnormal failure noted?  No
   r) Field person’s performance rating of barrier system?  Good
   s) Additional comments  Posts did not break. Posts and W-Beam pushed out of alignment.

IMPORTANT
♦ Photographic record of site needs to be taken. Photos should include deformation of the plastic posts along the railing, inside and outside the vehicle contact area.
♦ Samples of damaged posts are to be obtained from the site. Care should be taken in preventing any further damage to the posts in transit. These posts will be provided to ARC for examination and further research.