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# TECHNICAL MEMO

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| **TO:** | Crystal Morison C. Tech., Field Support Technologist, Central Region, Alberta Transportation | **DATE:** | February 15, 2011 |
| **C:** | Mike Damberger, P.Eng. , Construction Manager, Central Region, Alberta Transportation | **MEMO NO.:** | |
| **FROM:** | A.E. (Tony) Churchill, M.Sc., E.I.T., C.E.T. Transportation Engineer | **EBA FILE:** | E32101112.004B |
| **SUBJECT:** | Highway 2:18 to :24 Airdrie to North of Innisfail<br>Highway 2:30 to :32 Jct. Highway 2A to Leduc<br>Contract No. 7232/09, C.E. No. 253/08<br>Comparison of Shoulder and Ditch Installations of High-Tension Cable Barrier on Highway 2 | | |

## 1.0 INTRODUCTION

In July 2010, a high tension median cable barrier was installed on 122 km of Highway 2 from north of Airdrie to Red Deer and in the vicinity of Leduc. The total length of high tension cable barrier (HTCB) installed along the 122 km section of highway was 132.96 km. As Table 1 in Section 3 below shows, 77.70 km of HTCB (58% of the 132.96 km) were installed near the shoulder (near the top of the median sideslope) in the northbound or southbound direction along 66.16 km of highway. There are two sections of highway totalling 12.36 km (9.68 km near Red Deer and 2.68 km near Leduc) where HTCB was installed on the both sides of the median near the shoulder for a length of 24.46 km of HTCB which are included in the shoulder installation values above. The remaining 55.26 km of HTCB (42% of the 132.96 km) were installed in the median ditch along 55.84 km of highway.

Alberta Transportation (AT) has identified a number of questions regarding placement of the HTCB in the bottom of ditch versus near the shoulder placement and key among these is the potential relocation of the barrier from the shoulder to the ditch.

**Based on the information presented in this memo there is not an improvement in terms of safety or operations if the shoulder installations are relocated to the ditch and, therefore, it is not recommended that shoulder installations be relocated.**

This technical memo deals with the following topics which AT has asked EBA, A Tetra Tech Company (EBA) to address.

1. Briefly explain the rationale and advantages of locating the HTCB on the shoulder, i.e. on top of the median sideslope adjacent to the pavement, as opposed to ditch placement.
2. Based on the preliminary hit data provided by AT's Operations Manager, review the performance of the ditch versus shoulder installations of the HTCB.
3. Ascertain whether the shoulder installation of the HTCB has been hit by snow plows to date.
4. Provide a budgetary level cost estimate for relocating the shoulder HTCB segments to the ditch.

5. Provide a recommendation as to whether AT should consider relocating the shoulder HTCB segments to the ditch.

## 2.0 RATIONALE FOR LOCATION SELECTION OF HIGH TENSION CABLE BARRIER: SHOULDER VERSUS DITCH

The location of the cable barrier in the median must take into account many inter-related and sometimes conflicting factors and guidelines, including but not limited to the following.

1. The US Federal Highway Administration (FHWA) approves the proprietary HTCBs on the basis of tests conducted with specific vehicles hitting the barrier at specific speeds and angles. FHWA indicates the maximum design deflection at given post spacing, and also issues guidelines about "off-limit" parts of the median where the HTCB should not be installed due to changes in the vehicle centre of gravity or height and potential for under-riding or over-riding the barrier. According to the FHWA at the time of the HTCB design for Highway 2, HTCBs should not be installed on any median sideslope within 0.3 m to 2.4 m of the sideslope bottom; and an additional rule for 4:1 median sideslopes is that the HTCB should not be installed on the median sideslope further than 1.2 m from the top of the slope.

2. Since only one HTCB is normally used to protect both directions of traffic, there must be sufficient space to allow for the maximum specified deflection plus a safety margin (the sum being the desired room for deflection) between the HTCB and the median-side painted yellow shoulder lines in both directions.

3. The above Point 2 about sufficient space also applies to major hazards in the median such as bridge piers and overhead sign posts that do not have barrier to protect a vehicle from hitting them. For median hazards with guardrails to protect vehicles from colliding with the hazard, the HTCB should also have enough clearance from the guardrail, 0.9 metres, so that the HTCB posts have room to lie down when struck such that the guardrail can perform as intended.

4. Although the installation of the HTCB in the ditch centre would tend to satisfy Point 1 and Point 2 above, the ditch soils are often uncompacted, the ditches are subject to water accumulation, and there are often structures in the median such as catch basins or culvert outlets. The ditches are often uneven, with weak soil conditions, and may require extra grading and compacting and review of the overall drainage patterns. These factors tend to make the ditch installation of HTCBs more expensive. The soils on median sideslopes, on the other hand, are compacted and, therefore, much stronger. Another disadvantage of the ditch location is that snow can often submerge all or part of the cable barrier, thus rendering it inoperative. The HTCB located near the shoulder generally are not affected by snow drifts.

Shoulder installation of the barrier is preferred due to the disadvantages of ditch installation described above. Our contact with several US State Departments of Transportation indicates that in the vast majority of cases shoulder installation is preferred. Shoulder installation was the case on 77.70 km of the 132.96 km HTCB installation on Highway 2 where the conditions in Point 1, Point 2, and Point 3 above could be met. However, on the remaining 55.26 km these conditions could not be met, mainly because of the median being too narrow or other particular local situations. On these sections, therefore, the better location for the HTCB was the centre of the ditch. On some short sections of Highway 2, the placement conditions could

not be satisfied by either near the shoulder or ditch installation; the HTCB was therefore installed near the shoulder on both sides on these sections for a total highway length of 12.36 km and 24.46 km of HTCB.

In summary, because of the disadvantages of placing HTCBs in the ditch, installation of the HTCB near the shoulder is the preferred location along Highway 2. The main exceptions are locations where the median is too narrow to provide sufficient space for barrier deflection.

# 3.0 PERFORMANCE OF SHOULDER HIGH TENSION CABLE BARRIER INSTALLATIONS VERSUS DITCH INSTALLATIONS ON HWY 2

Collision data based on repairs completed on the full length of the HTCB from July 1, 2010 to December 31, 2010 was supplied to EBA by Mr. Russell Watts, AT's Operations Manager for the Central Region. This data set is comprehensive in terms of the physical damage to the HTCB; however, one of the limitations of this data is that there is no indication of the severity of the collisions that resulted.

Table 1 below presents the length of Highway and of HTCB sections near the shoulder as well as in the ditch of the median along Highway 2 together with the number, frequency, and rate of hits they received. The HTCB length indicates the total placement of the barrier on either the shoulder or the ditch and includes segments with HTCB on both median shoulders.

**Table 1: Cable Barrier Collision Experience for the Six-month Period July 2010 to December 2010 on Highway 2 between Airdrie and Red Deer and Leduc Vicinity**

| Location of HTCB | Highway Length (Highway-km) | HTCB Length (Cable-km) | Number of Collisions (Jul-Dec, 2010) | Traffic AADT (Vehicles per day) | Collisions Frequency (Collisions per Highway-km per year) | Rate of Collisions (Collisions per 100 million vehicle-km) |
|---|---|---|---|---|---|---|
| Near the Shoulder | 66.16 | 77.70 | 125 | 29,230 | 3.22 | 29.58 |
| In the Median Ditch | 55.84 | 55.26 | 77 | 27,810 | 2.79 | 27.45 |
| All | 122.0 | 132.96 | 202 | 28,610 | 3.04 | 28.80 |

The six-months of data for hits with the cable barrier presented in Table 1 shows that the location of the cable barrier (shoulder or ditch) does not have a significant influence on the hit rate per million vehicle-kilometres. The slightly higher rate for shoulder installation is to be expected since a higher proportion of errant vehicles will travel to the shoulder while many would recover before reaching the centre of the ditch. Two of the three known penetrations of the HTCB occurred in ditch installations and resulted in two injury collisions while the one known penetration of a HTCB shoulder installation resulted in property damage only. However, for a proper comparison it is necessary to take into account the severity of all collisions with the HTCB, for which full data is not yet available.

Collision data was provided by the AT Office of Traffic Safety for the segments with shoulder HTCB installation during the period July 1, 2010 to December 31, 2010. During this time, there were 61 reported collisions on these segments of the highway which resulted in 58 property damage only collisions and 3 injury collisions. Based on the maintenance contractor repair records, there were an additional 64 barrier hits requiring repairs which were unreported in the AT Office of Traffic Safety data and this is

obvious evidence of the low severity of collisions with the HTCB on the shoulder since vehicles are able to drive away.

## 4.0 HITS OF SHOULDER HIGH TENSION CABLE BARRIER BY SNOW PLOWS

The information provided by AT's Operations Manager indicates that there have been no hits of the shoulder installations of the HTCB by snow plows to date.

## 5.0 COST ESTIMATE TO RELOCATE THE SHOULDER HIGH TENSION CABLE BARRIER TO THE DITCH

Table 2 below shows the estimated "budgetary level" cost estimate for removing the near the shoulder cable barrier and re-installing the salvageable parts and new parts in the ditch. Details and assumptions made in arriving at the cost estimate are indicated with superscripts and noted below the table. It should be noted that given the restricted scope and budget for this technical memo the cost estimate presented is based on the assumptions stated. Given the obvious disadvantages of ditch installation, however, the estimate cost is considered sufficient to indicate that relocation from the shoulder is not cost effective. The cost for this work is estimated at $4.1 million.

**Table 2: Budgetary Level Cost Estimate to Relocate HTCB from the Shoulder to the Ditch**

| Item | Unit | Estimated Quantity | Unit Cost | Estimated Cost |
|---|---|---|---|---|
| Remove and Salvage Longitudinal Sections | m | 77,700 | $ 13.0 [1] | $ 1,010,100 |
| Remove and Salvage TL-3 Terminals | Ea. | 34 | $ 822.25 [1] | $ 27,957 |
| Remove and Salvage Non-crashworthy Terminals | Ea. | 24 | $ 892.92 [1] | $ 19,918 |
| Install Longitudinal Sections | m | 66,160 | $ 11.31 | $ 748,270 |
| Install TL-3 Terminals | Ea. | 34 | $ 715 | $ 24,310 |
| Install Non-crashworthy Terminals | Ea. | 24 | $ 776.45 | $ 18,635 |
| Supply Longitudinal Sections | m | 16,540 [2] | $ 52.49 [3] | $ 868,185 |
| Supply TL-3 Terminals | Ea. | 8 [2] | $ 2,445.34 [3] | $ 19,563 |
| Supply Non-crashworthy Terminals | Ea. | 6 [2] | $ 2,445.34 [3] | $ 14,672 |
| Grading/Drainage/Slope Improvements | km | 32 [4] | $ 31,015 [5] | $ 992,480 |
| **Subtotal** | | | | **$ 3,744,090** |
| Mobilization (10%) | Ea. | 1 | - | $374,409 |
| **Total** | | | | **$ 4,118,499** |

**Notes:**
1. Remove and Salvage cost assumed at 115% of the original installation cost presented in the construction summary report.
2. Supply of new longitudinal sections and terminals based on 25% replacement and 75% re-use of salvaged materials.
3. The unit cost for supply of new materials is assumed at 140% of the original supply cost.
4. Grading/Drainage/Slope improvements are assumed for 25% of the length of the new longitudinal sections and is doubled to consider both median sideslopes.
5. The unit price average for sideslope improvements for central region (2010) was used.

## 6.0 RECOMMENDATION

It is strongly recommended that no further consideration be given to removing the shoulder installation of the HTCB and re-installing it in the ditch. The reasons for the recommendation are summarized below:

- For reasons explained above, from an engineering and safety viewpoint, the preferred location for HTCB in depressed medians is on the median sideslope near the shoulder. Our contact with several US State Departments of Transportation indicates that in the vast majority of cases shoulder installation is preferred.
- The collision rate of shoulder installations of HTCB is higher than of HTCB ditch installations based on repair data. However, there does not appear to be a safety benefit of ditch installation in terms of injury reduction given the low severity of these collisions, considering the available collision data. Considering the known penetrations of the HTCB, there have been fewer penetrations of a lower severity for shoulder installation as compared to ditch installation.
- An update to the economic analysis of the Highway 2 HTCB installation considering construction, operations/maintenance costs, and the collisions between July 1, 2010 and December 31, 2010 indicates an overall benefit-cost ratio of 4.58 for a design life of 20 years for the existing placement.
- The estimated $4.1 million cost of relocating the HTCB from the shoulder to the ditch would not provide a benefit in terms of collision reduction.

## 7.0 CLOSURE

We trust this memo meets your present requirements. Should you have any questions or comments, please contact Mr. Churchill at your convenience.

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