

Alberta Transportation

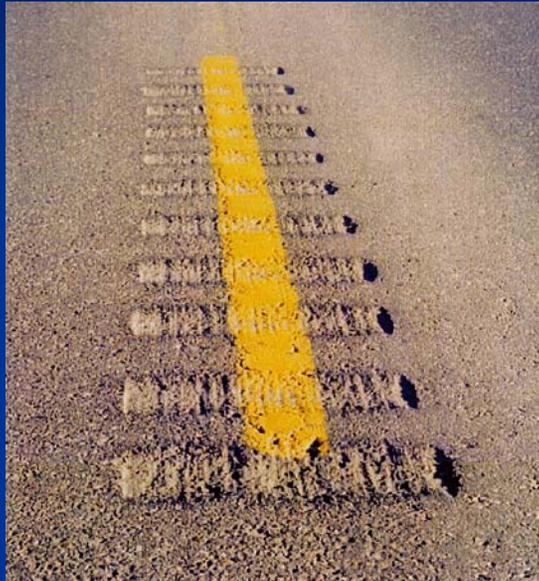
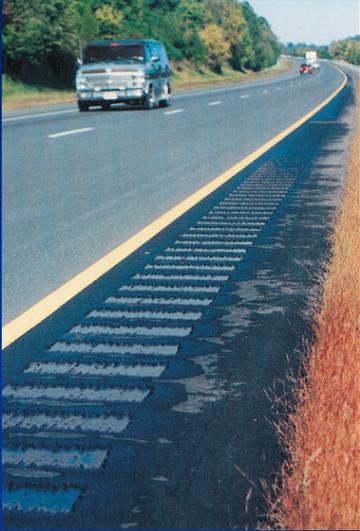
Rumble Strips

- C-TEP Lunch and Learn

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- July 2011

What are Rumble Strips?



- A preventative measure
 - A mitigative measure (make mild)
 - Audio tactile profiled markings
 - Give tactile vibration and audible rumbling
 - Reduce run-off-road incidents*
 - Reduce cross-the-centre incidents
 - Promote awareness of stop condition
 - Warn of hazards beside road
- * 40% of rural injury crashes are ROR type.



Why Use Rumble Strips?

- Rumble Strips are considered to be the most cost-effective safety measure that has not been universally adopted to date.
- Can reduce fatigue related crashes by between 20% and 80% (according to published studies).
- Payback periods are sometimes as little as two weeks, life is usually 20 years, therefore Benefit / Cost up to $\sim 500/1$.

Rumble Strips (cont.)

- Information obtained from experience, related literature and evidence shows that use of rumble strips is **the most cost-effective safety measure that has not been universally adopted to date.**
- Particularly useful during poor visibility conditions (pavement markings and other markers being obscured)

Rumble Strips (cont.)

- Help reduce Single Vehicle Run-Off-Road (SVROR) collisions due to driver fatigue on relatively long trips (20 to 60% reduction)
- Currently SVROR type of collisions accounts for 23% of all collisions reported on rural highways in Alberta

Rumble Strip Placement Locations



Shoulder Rumble
Strips



Centreline Rumble
Strips

Shoulder Rumble Strips

- Shoulder rumble strips are common in Alberta and many other jurisdictions in Canada and the USA and have been proven as a highly cost-effective measure
- Should be provided continuously along highways; rural; 60km/hr or greater
- Alberta Transportation's practice is to "mill" in.
- Expected reduction of 16% of all collisions in Alberta context

Centreline Rumble Strips

- Relatively inexpensive thus should be provided continuously along centreline of undivided highways, except:
 - In urban municipalities and
 - Within 300m of residences
 - Within 50m of the centre of intersections
- Rural; 60km/h or greater
- Priority based on frequency of head-on collisions
- Expected reduction of 14% of all collisions in Alberta context

Benefit/Cost Ratio Example



Average cost of a rural collision in Alberta (2004 - 2008)

- Fatal: $1113 \times \$1,345,068 = \$1,497,060,684$
- Injury: $16,870 \times \$100,000 = \$1,687,000,000$
- PDO: $89,642 \times \$12,000 = \$1,075,704,000$
- TOTAL # 107,625 \$4,259,764,684

- Average Cost/Collision = $4259764684/107625$
 - = **\$39,580**

Collision Cost Example: Rural Highway, 1500 AADT

- # Veh.km/km/yr = $1500 \times 365.25 = 547,875$.
- Typical collision rate = 96.60 / 100 million veh.km
- # collisions/km/yr = $(547,875 / 100,000,000) \times 96.6 = 0.53$
- Annual collision cost /km = $0.53 \times \$39,580 = \$20,948$.

Why Rumble Strips (continued)?

- Cost of **shoulder** rumble strips = \$1000/km/side
- Benefit = 16% reduction in all collisions (AASHTO)
- For example with AADT = 1500, Benefit (20 years) = $\$20,948 \times 0.16 \times 20 = \$67,034$
- Benefit / Cost = $67,034 / 2000 = 34$
- Payback Period = $20 \times 12 \text{ months} / 34 = 7 \text{ months}$

Why Rumble Strips (continued)?

- Cost of **centreline** rumble strips = \$1500/km
- Benefit = 14% reduction in all collisions (AASHTO)
- For example with AADT = 1500, Benefit (20 years) = \$20,948 x 0.14 x 20 = \$58,654
- Benefit / Cost = 58,654 / 1500 = 39
- Payback Period = 20 x 12 / 39 = 6 months

Rumble Strips

- Alberta Transportation has been installing rumble strips as a safety measure on Alberta highways since 1992.
 - Rolled-in continuous type before 1995
 - Milled-in type starting 1995
 - Milled-in type for stop condition (intersections).
Raised type discontinued in 1995 because of problems with snowplow operation

Rumble Strip Application Methods



Rolling-in Method



Milling-in Method

Rolling-in Method



Hairline cracking of pavement
at rolled in rumble strips

Advantages

- Simple and fast installation
- Low cost (approx. \$500 per lane-km)

Disadvantages

- For fresh and uncompacted pavement only
- Difficult to maintain quality control over alignment (lateral placement) and depth of rumble strips, and tearing on pavement

Rolling-in Method (cont.)

- Factors affecting quality
 1. Type, weight, speed and guiding device of drum roller
 2. Pavement mat temperature
 3. Weather
 4. Top size of aggregate in the hot mix

Milling-in Method



Wirtgen500 Milling Machine

Advantages

- For existing and hardened new pavement, therefore versatile and flexible
- Easy to maintain quality control over alignment (lateral placement) and depth of rumble strips

Disadvantages

- Higher cost (approx. \$1000 per lane-km); 2 to 2.5 times the cost of the rolling-in method. Cost has come down with larger quantity.

Implementation Process - 2011

- **Past:** rolled-in rumble strips, installed under construction contract or milled rumble strips installed through special contract.
- **Present:** milled rumble strips, installed in 3 ways:
 1. new surfacing projects.
 2. Highway Maintenance Contracts
 3. Stand-alone Rumble Strip contracts.

See Design Bulletin # 18, May 2011.

Considerations for Prioritizing Milled Shoulder Rumble Strip Projects

- Collision Rate and Frequency
- AADT
- Continuity
- Pay-back period
- Benefit/Cost Ratio over life of improvement for milled rumble strips

Previous - “Initial Program”

- 1) Install rumble stripping only on divided highways.
- 2) Hwy 2 from Edmonton to Calgary, excluding areas to be rehabilitated from 2003 - 2005.
- 3) Projects with highest NPV/Cost given next highest priority.

Previous “Initial” Program

Why Divided Highways?

- Longer routes and highest average AADT.
- Longer average trip length → increased driver fatigue.
- Higher speeds on divided hwys result in higher collision severity.

Divided and Undivided Highways

- 29% and 21% of collisions on divided and undivided hways in Alberta respectively are single vehicle run-off-road type (2002 to 2006 data)
- Rumble strips are a preventive technique for SVROR type collisions.

Alberta's Typical Annual Collision Record - Average for 2002 – 2009.

- Fatalities: 410
- Serious Injuries*: 3344
- Killed at intersections: 82
- Serious injuries at intersections: 982
- Killed on rural roads: 293
- Serious injuries on rural roads: 1593
- Portion of rural serious collisions that are Run-Off-Road type: 40 - 50% approximately.

*Serious injuries involve hospitalization.

What is AT currently doing?

Conceptual outline of annual safety program

- Rumble Strips \$15m
- Cable Barriers \$2.6m
- Enhanced Pavement Markings \$0.2m
- Impact Attenuators \$0.4m
- Pedestrian Countdown Signals \$0.7m
- Wider Pavement Markings: trial project (TAC)
- Fixed Hazard Removal \$0.35m
- Linear Delineation Systems \$0.2m
- Gateway Treatments: trial project \$0.5m

TOTAL : \$20 m/annum.

Rumble Strip Placement Practices

(Design Bulletin 18)

- The following changes (2006) have been made to rumble strip placement criteria:
 - Two lane highways with minimum shoulder width **1.4m** (was 1.80m)
 - Multi-lane highways with right shoulder of **1.4m** (was 1.8m)

Rumble Strip Placement Practices

- Continue...
 - Multi-lane highways with left shoulder of **0.6m** (was 1.0m)
 - At intersections with tapers, terminate and re-instate 60 m from taper
 - At intersections where there is no taper, terminate and re-instate 200 m from the intersection or as determined in the field.

Rumble Strip Placement Practices

- Continue...
 - Bridges and bridge approaches where the shoulder exceeds **1.4m** – install rumble strips beginning 100m prior to guardrail approach and end 10m prior to deck.
 - Rumble strips are not to be placed on bridge decks unless approved by the department as a “special” installation.

Rumble Strip Placement Practices

- Continue...
 - May install selectively at locations where hazards exist near travel lanes provided the right hand shoulder exceeds 1.4m e.g. railway crossing cantilever structures, raised islands etc.

Rumble Strip Placement Practices

- Centreline rumble strip depth 9mm +/- 2mm (was 6mm +/- 2mm)
- Shoulder rumble strip depth is 9mm +/- 2mm (was 8mm +/- 2mm)

SHOULDER RUMBLE STRIPS

(ranking by department)

Ranking	Hwy	cs	Road way	From	To	Length (km)	Width (m)	5yrs collisions (04-08)	Coll cost (\$)	Coll cost/km/yr (\$)	Benefit/km/yr	B/C
1	11	12	C1	18.8	19.18	0.38	12.2	43	1701940	895758	143321	1433
2	16	6	L1	10.36	11.5	1.14	14	76	3008080	527733	84437	844
3	2	10	L1	23.153	23.894	0.741	14	46	1820680	491412	78626	786
4	16	6	L1	8.83	10.04	1.21	14	70	2770600	457950	73272	733
5	2	24	R1	0	0.67	0.67	14.4	35	1385300	413522	66164	662
6	1A	6	C1	13.953	15.015	1.062	13.6	55	2176900	409962	65594	656
7	16	6	R1	9.13	9.47	0.34	14	14	554120	325953	52152	522
8	16A	14	L1	0.54	0.981	0.441	12.8	18	712440	323102	51696	517
9	40	42	L1	34.261	35.04	0.779	12.5	29	1147820	294691	47151	472
10	11	12	L1	20.3	21.92	1.62	16.1	59	2335220	288299	46128	461

Centerline Rumble Strips (ranking by department)

Ranking	Hwy	cs	Road way	From	To	Length (km)	Width (m)	5yrs collisions (04-08)	Coll cost (\$)	Coll cost/km/yr (\$)	Benefit/km/yr	B/C
1	11	12	C1	18.80	19.18	0.38	12.2	43	1701940	895758	125408	1872
2	1A	8	C1	13.95	15.02	1.08	13.8	55	2178900	409982	57395	785
3	40	42	C1	35.04	35.27	0.23	12.1	7	277080	243035	34025	454
4	2	52	C1	24.07	25.51	1.44	14.4	41	1622780	225386	31554	421
5	22	18	C1	10.00	10.99	0.99	13.8	27	1068660	215891	30225	403
6	1A	8	C1	15.02	19.10	4.08	18.8	103	4078740	199742	27964	373
7	2A	4	C1	13.13	13.55	0.42	17.4	9	358220	169629	23748	317
8	20	8	C1	0.00	0.35	0.35	11.5	7	277080	158320	22185	296
9	16	8	C1	11.74	12.27	0.53	15.8	10	395800	149924	20989	280
10	2A	4	C1	5.07	7.57	2.50	12.6	38	1504040	120323	16845	225

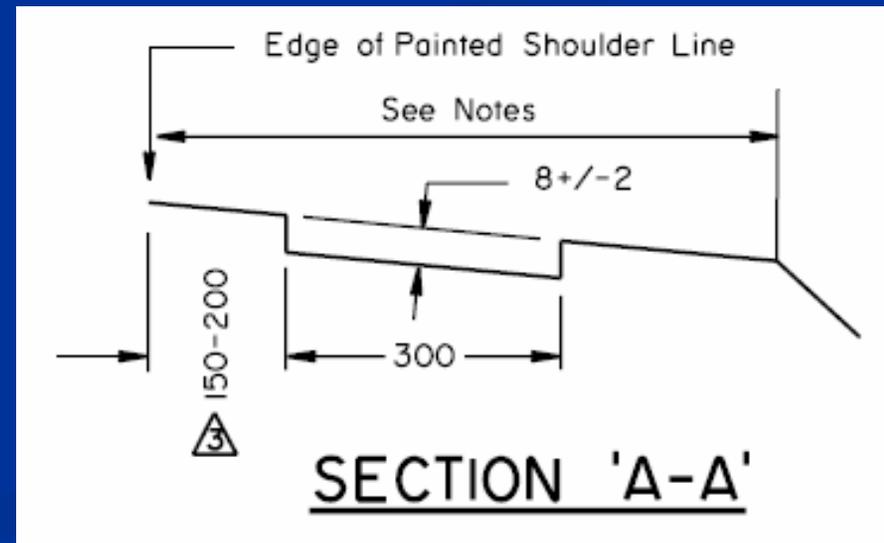
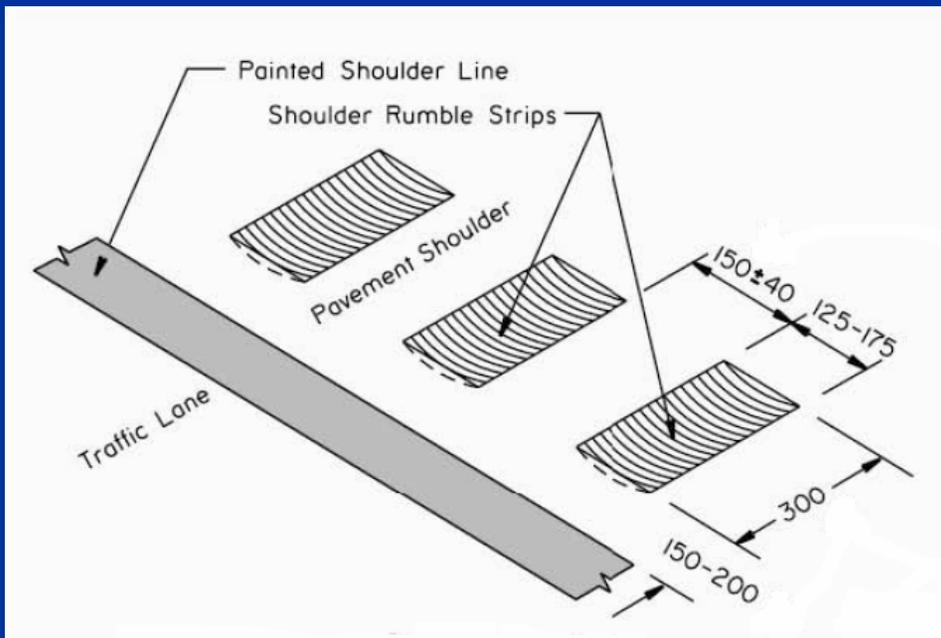
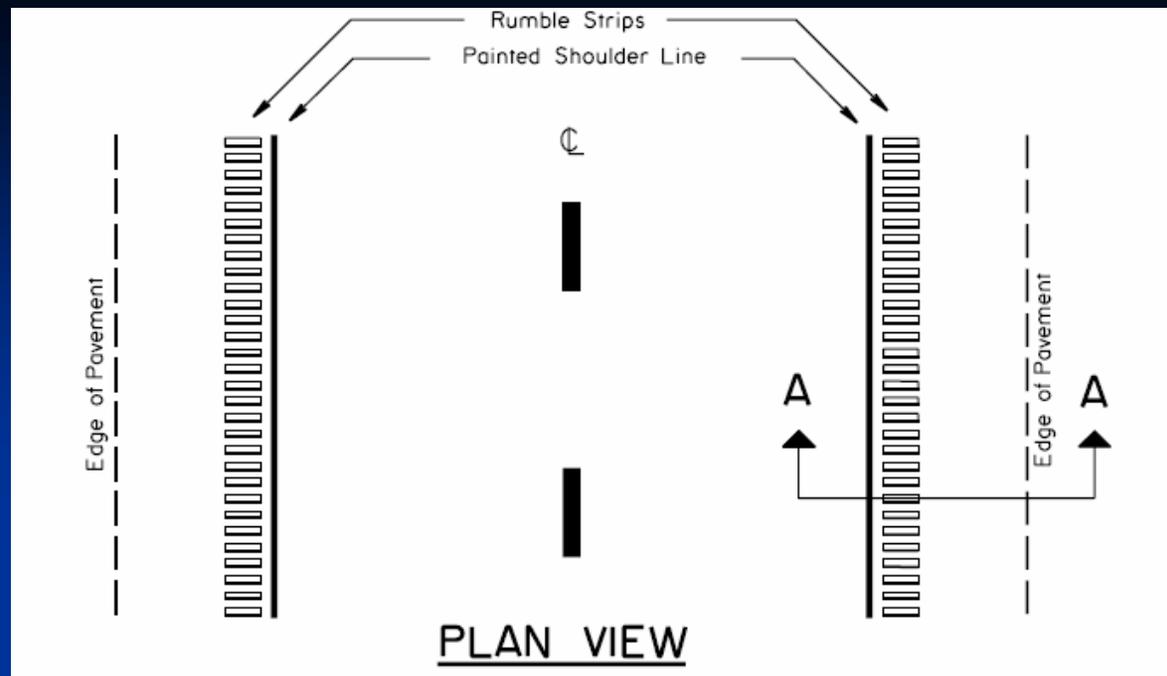
Typical Standards and Layout

- CB6 drawings on web

- Continuous Milled Rumble Strips for Shoulders
- Intermittent Milled Rumble Strips for Shoulders
(*Obsolete-AT Standard*)
- Milled Rumble Strips for Centreline
- Milled Rumble Strips for Stop Condition

Typical Layout for Continuous Milled Rumble Strips for Shoulders

AT CB6-3.52M1



Milled-In Continuous Rumble Strips on the Inside Shoulder of a Segment of Highway 16 (Divided), West of Edmonton, Alberta (1997)



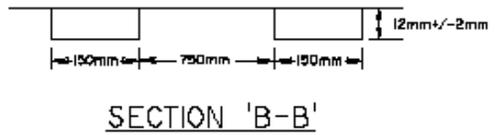
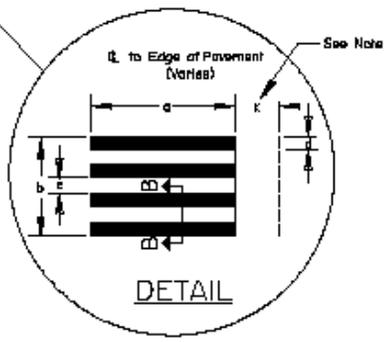
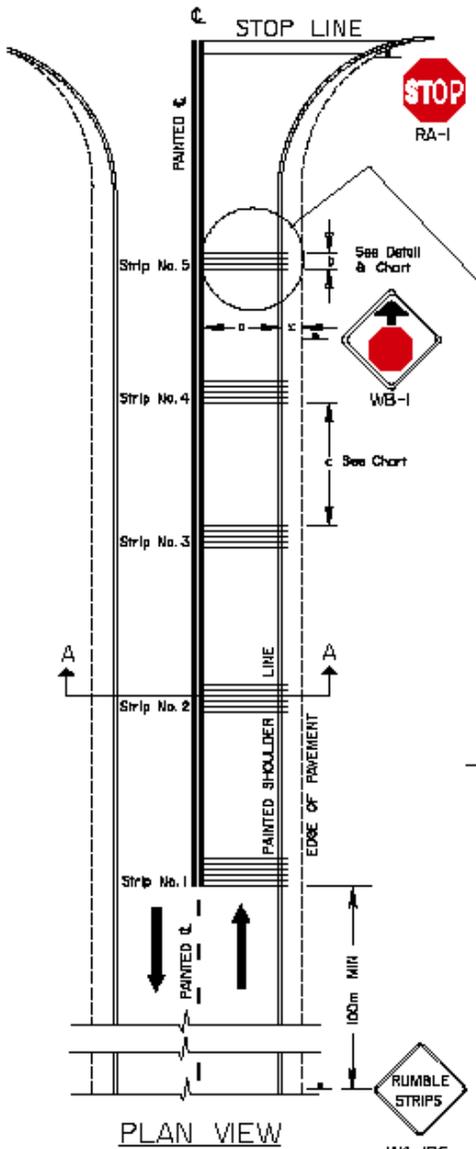
Milled Rumble Strips Centreline

- Previous practice - install selectively at locations where there is the highest probability of need. Primarily on horizontal curves on busier highways.
- Current practice - Centreline milling along passing and no passing zones (was only at double barrier lines, no passing zones).
- Warning signs installed.
- Before and after collision experience will be monitored.

Typical Layout for Milled Rumble Strips Stop Condition CB6-3.52M3 (April 2001)

DETAIL MEASUREMENTS FOR MILLED RUMBLE STRIP LAYOUT

Station	Station	Strip No.	b Strip Length (m)	c Strip Spacing (m)	Number of Bars	d Bar Width (mm)	e Bar Spacing (mm)
000	Stopline						
90.00	92.85	5	2.85		4	150	750
135.00	138.75	4	3.75	49.15	5	150	750
185.00	189.75	3	3.75	46.25	5	150	750
240.00	244.85	2	4.85	31.25	6	150	750
300.00	300.65	1	4.85	55.65	6	150	750



⚠	REVISED TO ACCOMMODATE CYCLISTS	B.K.	04/01
⚠	NOTE ADDED TO SECTION A-A	T.N.	09/98
⚠	REV. PLATE AND RENUMBERED FROM TEB 518	S.L.	03/98
No.	REVISIONS	BY	DATE

Approved:

ORIGINAL SIGNED BY ALLAN KWAN

Executive Director, Technical Standards Branch

Date: MARCH 08/98

TYPICAL LAYOUT FOR MILLED RUMBLE STRIPS FOR STOP CONDITIONS

Prepared By: T.N. Checked By: B.K. Scale: N.T.S. Dwg No.: CB6-3.52M3

NOTE:
 A CLEAR AREA (1m WIDE OR THE WIDTH OF THE SHOULDER) WHICHEVER IS LESS, SHALL BE LEFT ADJACENT TO THE EDGE OF PAVEMENT TO ACCOMMODATE CYCLISTS.



Milled Rumble Strips Stop Condition

- Based on operational experience (collision history).
- Previously lane strips extended to the edge of paved shoulder to allow transverse drainage and reduce icing problems.
- Revised later to outside edge of shoulder line to allow a smooth path of travel for cyclists.

Collision occurred on I-90 in Montana



- Driver fell asleep at the wheel.
- Struck end of the guard rail.
- The guard rail came through the right headlight, engine compartment, firewall, glove box, passenger seat, rear seat and exited out the driver's side rear window.
- 120 Linear Feet of guard rail threaded through the suburban
- Driver was not injured.

Questions?