Stability of motorcycles on audio tactile profiled (ATP) roadmarkings

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We have no evidence that ATP roadmarkings create any significant instability issues for motorcycles.
New Zealand adopted the raised-profile type of ATP roadmarkings - Trials in 2004 - Expanded use since 2008/2009

Early usage of ATP roadmarkings was predominantly as edge lines with expectations of low rates of being traversed

Usage of ATP roadmarkings has evolved and increased so that ATP roadmarkings are now where they may be more routinely traversed

Other studies have associated the use of ATP roadmarkings with a 15 to 20 percent reduction in crashes - Could specific effects of ATP roadmarkings for motorcycles be masked by a general trend?
Why research ATP roadmarkings and motorcycles?

Public interest and parliamentary questions

While there is no evidence to suggest that ATP roadmarkings would cause cyclists to lose control or crash, cyclists would prefer to avoid them and they may pose a danger to cyclists if they are encountered unexpectedly or if the cyclist is already not in full control of their bike.

There is limited information regarding the risks (or benefits) that ATP roadmarkings pose to cyclists and motorcyclists. [...] Some motorcyclists have indicated that as long as they can see them, they can take reasonable steps to avoid them.

Paint in the wet is slippery, and the 'rumble strips' used now are worse. Both slippery paint and the grooves in the 'rumble strips' will throw a leaned over motorcycle off line.

Rumble strips are nasty, whether on the centre line or the side line (a motorcycle cornering line will always approach near the road side edge marking).
ATP roadmarking dimensions
- Other studies inspected road surface irregularities and bicycle stability
- Findings used in guidelines for ATP roadmarkings dimensions

ATP roadmarking usage
- Edge line with clear shoulder for cyclists to ride in
- Avoiding usage or provide gaps where cyclists would have to cross the

Do the considerations for bicycles apply equally to motorcycles?
- Cyclists benefit from ATP roadmarkings through better lane-keeping by motorists, but this benefit may not apply to motorcyclists who use the road differently
- The ATP roadmarking dimensions have been tested for bicycles at cycling speeds but the stability may not be the same for motorcycles at higher speeds
We are clear about the benefit of ATP roadmarkings overall but we are unclear about the potential instability issue for motorcycles.

Three stages:

- **Existing evidence:**
  Analysis of existing crash records

- **Emerging evidence:**
  Review of associated literature

- **More evidence:**
  Simulation testing of motorcycles ridden on ATP roadmarkings

If these three stages do not indicate an instability issue for motorcycles, then based on the established benefits of ATP roadmarkings, the current practices can be continued.
Analysis of existing crash records

- **CAS (Crash Analysis System)**
  - Database of coded traffic crash reports

<table>
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<th>CRASH ROAD</th>
<th>CRASH DIST</th>
<th>CRASH DIRN</th>
<th>SIDE ROAD</th>
<th>CRASH ID</th>
<th>CRASH DATE</th>
<th>CRASH DOW</th>
<th>MMVT DESC</th>
<th>CAUSES</th>
<th>ROAD WET</th>
<th>LIGHT</th>
<th>WTHR</th>
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<td>29/12/2003</td>
<td>Mon</td>
<td>1042</td>
<td>CAR1 SBD on SH 2 lost control; went off road to left, CAR1 hit Fence</td>
<td>CAR1 too far left/right, lost control while returning to seal from unsealed shoulder, inexperience</td>
<td>Dry</td>
<td>Bright</td>
<td>Overcast</td>
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<tr>
<td>2/858/0.324</td>
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<td>S</td>
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<td>2756014</td>
<td>17/10/2007</td>
<td>Wed</td>
<td>645</td>
<td>CAR1 SBD on SH 2 lost control turning right, CAR1 went Over</td>
<td>CAR1 lost control due to road conditions. FMV: road slippery</td>
<td>Wet</td>
<td>Overcast</td>
<td>Heavy Rain</td>
</tr>
</tbody>
</table>

- Contains original traffic crash reports
  - Written descriptions of crash
  - Driver and witness interview notes
  - Details on damage, injuries, obstructions
- 90 motorcycle/moped crashes were found to have occurred where ATP roadmarkings were likely to be present
- Manual review of the traffic crash reports found no reports indicating evidence of the involvement of ATP roadmarkings in the crash

- Police, witnesses, motorcyclists have many things to observe or remember
- There is no “prompt” ATP roadmarking field on the traffic crash report form
- However, if there was a clear issue we might expect to see some evidence within 90 traffic crash reports
Review of associated literature

- Impacts on motorcycles of contacting ATP roadmarkings
  - This study and others have found no reports of motorcycle crashes involving ATP roadmarkings
  - Roadside video in the United States observed no directional changes or unusual riding behaviours as motorcycles crossed milled-in ATP roadmarkings
  - Field trials in Japan, Germany and the United States had motorcycles riding over milled-in ATP roadmarkings with no adverse outcomes
  - Field trials in the United Kingdom and the United States had motorcycles riding over and braking on raised-profile ATP roadmarkings with no adverse outcomes
Review of associated literature

- Impacts on motorcycles of contacting other surface irregularities
  - A study of motorcycle crashes reported on the surface irregularities present at the crash sites finding the road surface actively contributed to 15% of the motorcycle crashes
  - Field trials in the United States had motorcycles riding over grooved roads with no adverse outcomes

- We also found...
  - Implications of assumed harm such as “some motorcyclists have indicated that as long as they can see the ATP roadmarking ribs they can take reasonable steps to avoid them”
  - Backing-down from results of studies
  - Very small sample sizes
Simulation testing of motorcycles ridden on ATP roadmarkings

- Vehicle crash and trajectory simulation modelling software: PC-Crash
  - Three-dimensional road element
  - Vehicle manufacturer data on physical characteristics and performance parameters of vehicles
  - For vehicle(s), specify the path to follow during the simulation, with any sequence of speed, acceleration, braking...
  - Kinetic model determines vehicle response during the simulation as the vehicle performs the specified movement as far as possible under application of the laws of physics
Verify PC-Crash for our intended application

- Response to the details of ATP roadmarkings
  - Motorcycle pitch during travel over single ATP roadmarking ribs of 3 mm, 6 mm, and 9 mm high
Verify PC-Crash for our intended application

- Verify PC-Crash by comparing with full-scale physical testing
  - Quantities that can be measured by both PC-Crash and a real-life motorcycle

roll  yaw  pitch
You will need:

- Full-scale physical testing
  - Instrumented motorcycle
    (gyroscopes, accelerometers, power supply, data acquisition system)
  - Motorcyclist
  - Specified path
  - Without and with ATP roadmarkings

- Equivalent PC-Crash situation:
  - Select same motorcycle
  - Set same motorcyclist weight
  - Set same specified path
  - Without and with ATP roadmarkings
    of same dimensions and layout
Response from instrumented motorcycle (red) and PC-Crash (blue)

100 metre radius corner, 30 km/h, 9 mm high rib

50 metre radius corner, 30 km/h, 9 mm high rib
Steering angles and heading angles

The plan:
- Simulate a motorcycle ridden on a road without ATP roadmarkings
- Simulate a motorcycle ridden on that road with ATP roadmarkings
- Compare the motorcycle’s stability or handling
Simulation situations

- Wide/poor approach to a “tight” corner
- Wet road surface
- Two speeds
  - 100 km/h
  - 140 km/h
- Three braking scenarios
  - No braking
  - Some braking (50 %)
  - Maximum braking (100 %)
Simulation situations

- Three motorcycles

  - Without ATP roadmarkings:
    - Two speeds, three braking scenarios, three motorcycles
  
  - With ATP roadmarkings:
    - Two speeds, three braking scenarios, three motorcycles

- Makes 36 situations!
Outputs from each simulation situation

- 100 km/h, 50 % braking, sports bike
- Without ATP roadmarkings (red) and with ATP roadmarkings (blue)
Analysis of existing crash records
Review of associated literature
Simulation testing of motorcycles ridden on ATP roadmarkings

We have no evidence that ATP roadmarkings create any significant instability issues for motorcycles

Based on the established benefits of ATP roadmarkings, the current practices can be continued