GEOPAVE
MATERIALS TECHNOLOGY

RESEARCH AND DEVELOPMENT REPORT

Management of Audio Tactile Edge Line Markings

Final Report
Project No. 952

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FINAL REPORT

MANAGEMENT OF AUDIO TACTILE EDGE LINE MARKINGS

Project No. 952

by

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Abstract

This R&D project No.952 "Management of Audio Tactile Edge Line Markings" considered whether the audio and vibration characteristics of the audio tactile edge line markings (ATELM) were compromised after various maintenance treatments.

This report investigates the management of audio tactile edge line markings (ATELM), at 20 sites along the Calder Highway/Freeway between Kyneton Bypass and Sea Lake. The performance of ATELM was subjectively assessed for audio and vibration characteristics after various maintenance treatments had been completed.

This investigation has found that the audio tactile line markings can still be effective after having one reseal, preferably 7mm placed over them and still maintain a reasonable audio and vibration characteristics.

Key Words

Disclaimer

VRPN

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Executive Summary

VicRoads provides Audio Tactile Edge Line Marking (ATELM) as a road safety measure designed to reduce the likelihood of single vehicle run-off road accidents by providing the driver an audio signal and vehicle vibration as notification of imminent danger. Studies have shown when used as an alerting device they were effective in reducing crashes by up to 75%.

This R&D project No.952 "Management of Audio Tactile Edge Line Markings" considered whether the audio and vibration characteristics of the ATELM were compromised after various maintenance treatments.

The use of ATELM in Victoria has increased considerably since their introduction, however the expectations of performance of ATELM, and an understanding of the most effective maintenance practices for both the ATELM (maintaining the effectiveness of both the audio signal and the vibration responses) and adjacent pavement surfacing, are limited. The literature search has provided substantial details of ATELM usage and applicability and their success in reducing run-off accidents but showed little details of maintenance practices.

This R&D project No.952 "Management of Audio Tactile Edge Line Markings" has found that the audio tactile line markings can still be effective after having one reseal. The results of this project show that a size7mm seal can be placed over the ATELM and still maintain reasonable audio and vibration characteristics.

1. Introduction

This project relates to the 2005/06 Road System Management Research and Development Question: "What performance is required from pavements and surfaces to meet VicRoads goals and objectives, and how can this performance be measured and most cost-effectively delivered?"

The Research and Development (R&D) Project No.952 assists in addressing this question by investigating the Management of Audio Tactile Edge Line Markings (ATELM).

1.1 Background

VicRoads provides ATELM as a road safety measure designed to reduce the likelihood of single vehicle run-off road accidents.

The use of ATELM in Victoria has increased considerably since their introduction, however the expectations of performance of ATELM, and an understanding of the most effective maintenance practices for both the ATELM (maintaining the effectiveness of both the audio signal and the vibration responses) and adjacent pavement surfacing, are limited.

It is expected that the outcomes of this research project would result in clearer guidance for the effective implementation and maintenance of ATELM key characteristics. This research report looks at the current maintenance practices at sites with ATELM and using a subjective test to assess the audio and vibration responses of the resealed pavement.

1.2 Project Aim

The aim of this project was to determine the effectiveness of ATELM management practices, with a focus on:

- Pavement surface resealing activities;
- Relocation of ATELM (eg passing lanes, widening and turning lanes); and
- Renewing ATELM

2. Method

2.1 Literature Review

A literature review was undertaken to identify relevant pavement maintenance practices relating to surfaces adjacent to or beneath the ATELM. Research of local, interstate and international practices relating to the implementation, performance and maintenance of ATELM was undertaken to identify relevant design standards and performance requirements to ensure effectiveness (audio and vibration responses) of these installations after various maintenance treatments.

The major sources of this information were from local and international highway authorities, research and industry bodies, including:

- Other Australian Road Authorities, e.g. RTA NSW, Queensland Department of Main Roads, Transport SA;

- Transit New Zealand;
- Transport Research Laboratory, UK;
- Transportation Research Board, USA;
- Austroads;
- ARRB Group;
- Road Marking Industry Association of Australia; and
- Previously undertaken VicRoads research.

2.2 Identification and Investigation of Local Management Practice of ATELM

In consultation with VicRoads' Northern and Western Regions, a desktop study was undertaken to firstly identify candidate sites for investigation. Suitable sites for investigation would have sufficient information available to be able to address the objectives of this research project. This information could include:

- Maintenance treatment of ATELM and adjacent pavement surfacing, including considerations relating to the ATELM that may have influenced maintenance treatment selection;
- Regional staff's perception of the effectiveness and performance of the ATELM and their chosen maintenance practices;
- Intervention levels typically adopted for the repair or replacement of ATELM; and
- Other relevant information identified following the literature review.

2.3 Field Performance Evaluation of ATELM

The aim of the performance evaluation of ATELM was to determine the relative effect with respect to audio and vibration generation on a variety of different conditions found during the desktop study.

As part of the evaluation process, subjective in-vehicle noise testing was conducted, solely based on driver perception utilising a standard test vehicle. The testing vehicles comprised of available fleet vehicles from GeoPave, eg a Holden Commodore or Ford Falcon station wagon. However, the effectiveness of ATELM for heavier vehicles (eg. semi-trailers, and trucks) was not assessed as part of this project.

Testing sites that fulfilled the following conditions were assessed:

- Undisturbed ATELM; (ie. that conform with the current profile specification)
- ATELM that have been sealed over during a maintenance treatment;
- Aged ATELM;
- Where ATELM have been removed and new ATELM replaced;
- Physically damaged ATELM; and
- In addition sites where surfacing works have been undertaken adjacent to ATELM, without affecting the ATELM.

Repeat runs were undertaken to provide increased confidence of the subjective assessment of noise and vibration. The performance evaluation did not include a study of criteria relating to the

physical nature and performance of the materials used, or the implementation procedures utilised when installing the ATELM.

3. Results

3.1 Literature Review

The literature review has provided substantial details of ATELM usage and applicability and their success in reducing run-off accidents but little details of maintenance practices. A number of authors have alluded to the lack of detail regarding maintenance practices. A synopsis of the findings is provided below.

3.1.1 Noise Generation Characteristics of Non-Standard Profile Edge lining.

Author: ARRB, Transport Research, Evan Ramsey, May 1999, RC90200

ARRB Transport Research conducted an assessment of the noise levels produced by a vehicle travelling on recently installed profile or tactile edge lining (ATELM) on the Hume Freeway north of Benalla. VicRoads had concerns that the profile edge lining was below the acceptable standard, and required an independent assessment to compare in-vehicle noise levels generated by the suspect edge lining in comparison to the acceptable edge lining.

Some of the findings of this assessment were:

- Data from the 25 test sections was compared to the results obtained from 11 runs taken from acceptable standard audio tactile edge line marking by constructing an 85 percent confidence interval around the mean of the results.
- An increase in the sound pressure level (SPL) of 3dB(A) over the background noise level was generally regarded as being required for noise generated by audio tactile edge line marking to still be noticeable in a noisier environment.
- AS4049.2 (1994) does not specify what constitutes an adequate noise signal from this type of product.
- Standard audio tactile line marking average SPL is 77.9dB(A)
- A test section had been resealed (size not stated) the SPL was significantly lower at 75.8dB(A).
- An increase in SPL of 3dB(A) corresponds to a doubling of the sound pressure level (SPL). As a rule of thumb, this 3dB(A) criteria is used to signify that a change in the sound source's intensity is noticeable to the human ear.
- In defining a standard for audio tactile edge line marking, two approaches can be taken: prescriptive dimension based approach, or a performance based approach using a measure such as increase in sound pressure level (SPL) above the background.
- Of the 25.6 kilometres tested, 3 sections totalling to a length 4.9 kilometres, that is 20 percent, were found to have significantly lower sound pressure levels (SPL) than the standard ATELM.
- A "Svantek 912A" precision sound level meter was used to record the SPL's , within the vehicle.

3.1.2 Tactile Edge Markings, Calder Highway Bendigo, Noise Investigation

Author: David Ford Material Technology Dept. 25 March 1993, Report No.28B0231.

This investigation was carried out to assess the noise levels adjacent to the ATELM along the Calder Highway at Bendigo. The investigation was commissioned as a result of complaints received from nearby residents, i.e. outside the vehicle.

- Comparison was made with similar marking on the Western Highway at Ballarat.
- At Bendigo vehicles running on the tactiles generated pass by noise levels 7 to 8dB(A), with the frequency at 200Hz dominating the noise, this could be considered loud and obtrusive. The audio tactile "bars" were at 100mm centres.
- At Ballarat vehicles running on the tactiles generated pass by noise levels 2 to 3dB(A). The audio tactile "bars" spacing were 200mm centres.

Noise levels from the closer spaced audio tactile edge line marking was significantly higher at the Bendigo location (100mm) than that being generated at Ballarat (200mm).

3.1.3 Tactile Edge line Trials, South Gippsland Highway, Cranbourne, Environmental Noise Investigation.

Author: David Ford, Material Technology Dept. 20 December 1993, Report No.38B0039.

Prior to the widespread use of ATELM, a study of the noise generated by different profiles was undertaken. The following results were recorded:

- Profile (Bar) Spacing.

50mm spacing,	Noise level Increase 7-10dB(A)
200mm spacing	Noise level Increase 5-7dB(A)
450mm spacing	Noise level Increase 2-3dB(A)

- Profile (Bar) height

  Environmental noise adjacent to audio tactile line marking was found to be independent of the 'bar' height, (for 4, 6, 8mm bar heights).

- This report recommended 450mm spacing with a compromise to use 200mm spacing, providing a 5 to 7dB(A) increase in noise levels, above the background.

3.1.4 Edge Line Audible Markers, Hume Freeway Trial, Environmental Noise Measurements.

Author: David Ford, Material Technology Dept. 19 December 1996, Report No.68B0042.

An investigation to determine the comparative environmental noise levels of audible edge line markers placed at 3 different spacing's was undertaken. This investigation is similar to the study carried out above (Section 3.1.3).

- The current VicRoads standard audio tactile edge line ATELM, thermoplastic at 200mm spacing recorded a noise level increase of 8.9dBA.

3.1.5 The Effect of Profile Linemarking on In - Vehicle Noise Levels

Author: Peter Cairney ARRB, February 1994, Report No. WD RS 94/001

This investigation was concerned with vehicles running over audio tactile line marking and the audible noise generated, warning the driver that the vehicle had run over the edge line. The project aimed to determine the minimum height and spacing of profile edge line material, to provide a reliable auditory signal to drivers. The study investigated the noise generated in 3 vehicles (medium sedan, 4-wheel drive, and a Semi trailer, loaded and unloaded) at speeds of 60, 80, and 100Km/hr. The study concluded that none of the profile markings used in this study could be considered to give an effective auditory cue to truck drivers, although they would still benefit from the improved optical guidance. The 6 & 8mm high materials, at either 200mm or 50mm spacings, generally gave an adequate audio signal for both sedans and 4-wheel drive vehicles.

3.1.6 Contract Report: Audio-tactile Linemarking, Queensland Transport

Authors: Peter Cairney & Tan Hee-Wee, ARRB, Report No. CR OC4776, December 1996.

The Transport Technology Division of Queensland Transport (QT) commissioned ARRB Transport Research to conduct a project on the applications of audio tactile edge line marking (ATELM). The specific objectives of the project were:

(a) To conduct a literature review of audio tactile use on roads particularly for Australian conditions.

(b) Undertake an economic performance/cost comparison between conventional line marking and audio tactile edge line marking, including capital costs, maintenance costs and service life considerations.

(c) Determine product limitations and product specifications; and

(d) To develop traffic engineering guidelines on the use of audio tactile edge lines.

Some of the outcomes from this project were:

- Two sites in the Bundaberg District, which had parts of the audio tactile line marking covered by a new seal (size of seal not stated). Those sections covered by sealing still provide reasonable audio effect when driven over by cars.
- Rehabilitation of ATELM was an uncertain process. It is very expensive to scrape/ grind off old material before putting down new materials. Although some low-cost options may be effective in maintaining the marking throughout the life of the surface, such as repainting, these had not been carried out to a sufficient extent to either give a true indication of cost or inspire confidence in their efficacy. This has proved a barrier to the widespread uptake of ATELM.
- VicRoads seem not to have experienced the same problems with loss of ATELM through pavement edge failure experienced in Queensland. It has been used only on roads with adequate sealed shoulders (1m wide or greater). The most usual application has been on long straight sections with adverse crash history.
- Premature failures appear mainly due to 3 factors: edge failure, shoulder failure, and being covered in course of shoulder and edge maintenance.
- The life of ATELM seemed to be inconsistent to those suggested by the manufacturers.

3.1.7 Rumble Strips Development of guidelines for their use in New Zealand

Authors: D Munster, D Wong-Toi, M Owen and V Dravitzki, ARRB Transport Research Conference, 19th 1998 Sydney.

Historically the use of rumble strips (ATELM) in New Zealand has been very limited, but lately has been increasing. Transit New Zealand sought to review their use and effectiveness both internationally and throughout New Zealand. This was with regard to developing a policy for their future use. The review consisted of case studies, guidelines and specifications.

Some of the findings were:

- In car noise; do the strips create in car noise that is noticeable to drivers? Initially there was a 10-15dBA increase in noise above the surrounding road surface. After 10 months this had reduced to 8-12dBA above the surrounding road surface.
- The main mode of wear was identified as loss of bonding from the underlying surface and applying the line to a dirty road surface had been identified as a cause of premature failure, ie. loss of ATELM profile bars.

3.1.8 Centre for Automotive Safety Research; Edge Delineations.

Authors: JE Woolley and AJ McLean. Report No.CASR025, August 2006

The Motor Accident Commission (MAC) has previously sponsored a trial of audio tactile pavement markers on a section of the Dukes Highway immediately east of Keith, South Australia. The trial involved the innovative use of raised pavement markers (with the propriety name Polydots) at regular intervals along a painted edge line in order to keep costs down compared with thermoplastic ATELM.

MAC has asked the Centre for Automotive Safety Research (CASR) to comment on the relevance of this treatment including its compliance with design rules, its cost effectiveness when compared to other treatments and any safety issue with its use.

Some of the outcomes from this study were:

- The need to consider ongoing maintenance of audio tactile line treatments. Given an assumed field life of 4 years, no road authority has yet determined how to best maintain sections that have failed or been removed with regular road works. It is also unclear as to how complete sections would be replaced once their useful field life had expired. Victoria and Tasmania simply reapply the audio tactile line marking over sections which have failed.
- Conclusions and Recommendations (part only)
    1. Thermoplastic ATELM should be used as a fatigue driving counter measure
    2. The results of centreline ATELM in Victoria and NSW should be monitored; it is likely this will become the next major use of ATELM throughout the Australian Road network.
    3. Having completed coverage on the major highways, consideration should be given to the application of ATELM on sections of road where there is a high prevalence of run off road crashes regardless of whether a sealed shoulder is present or not.

3.1.9 Contract 5844: Defects in the Profiled Line marking

Authors: Ernest Selvadurai, VicRoads Western Region, Oct-Nov 2004

This profiled edge line project was constructed under Contract No.5844, as part of various line marking improvements along the Western Highway between Djerriwarrh Creek and South Australian border. The total length of the profiled edge line applied was 485.56Km

Defects found included:

- Adherence of thermoplastic marker to underlying pavement.
- Colour deterioration suggesting thermoplastic has been over heated or reheated too many times.

- Voids under the audio thermoplastic marker, (ATELM) ie not full contact with underlying material.
- Audio thermoplastic marker (ATELM) being brittle and breaking away when trafficked.
- Pin holing of audio tactile thermoplastic (attributed to trapped moisture or air).

3.1.10 Summary of Literature Search

The following are some of the key outcomes from the literature search:

- An increase in SPL of 3dB(A) corresponds to a doubling of the sound pressure level (SPL). As a rule of thumb, this 3dB(A) criteria is used to signify that a change in the sound source's intensity is noticeable to the human ear.
- None of the profile markings used in this study could be considered to give an effective auditory cue to truck drivers, although they would still benefit from the improved optical guidance. For cars and 4 wheel drives, generally, the ATELM gave an adequate audio and vibration response.
- Two sites in the Bundaberg District, which had parts of the audio tactile line marking covered by a new seal (size of seal not stated). Those sections covered by sealing still provide reasonable audio effect when driven over by cars
- The main mode of wear was identified as loss of bonding from the underlying surface and applying the line to a dirty road surface had been identified as a cause of premature failure, loss of ATELM profile bars.
- Given an assumed field life of 4 years, no road authority has yet worked out how to best maintain sections that have failed or been removed with regular road works.
- It appears the ATELM can be sealed over (in some cases) and still provide appropriate audio and vibration performance. However the type and size of reseal undertaken is not known.

3.2 Site Selection

GeoPave sought the assistance of VicRoads employees, to provide candidate sites for this project. A number of key parameters were selected to enable a good cross section of sites to be tested (see Section 2.3). The Calder Highway/Freeway between the Kyneton Bypass and Sea Lake provided a good range of sites for this project. The sites selected for investigation from the desktop study are shown in Table 1.

TABLE 1 Test Site Details

Criteria	Site ID	Location Calder Highway / Freeway	Treatment and Seal size	Observations
1. Sites Without ATELM				Not included in this project.
2. New ATELM Sites	2A	126-132Km	Installation mid 2005	Very good condition between Tourist marker and Mennes Lane *Reasonable*
3. "Old" ATELM sites	3A	140-142Km, South of Kangaroo Flat	50mm spacing of ATELM	Recently re-line marked using paint. *Reasonable*
	3B	230-250Km Between Wedderburn and Charlton	200mm spacing of ATELM	Old tactile in good condition, *Reasonable*
	3E	124-124.5Km	200mm spacing of ATELM	Very old ATELM cracked some breakaway and flattened. *Reasonable*
4. Sites where ATELM have been sealed over	4B	216.5-217 South of Wedderburn	Geotextile 14/7mm seal inside ATELM,	Underlying tactiles still visible. *Medium*
	4D	106.4-107.2	Geotextile 14/7mm seal Elphinstone	Geotextile seal 14/7mm over ATELM *Medium to Poor*
	4E	169.5-171.3Km	7mm Seal	7mm seal over audio tactiles *Reasonable*
	4F	175.1-180Km	7mm Seal	7mm seal over audio tactiles *Reasonable*
	4G	180-184.2Km	10mm seal on running lanes /7mm shoulder Seal	7mm seal over audio tactiles *Reasonable*
	4H	214.2-2.16.5	10mm Seal	10mm seal over audio tactiles *Medium*

Criteria	Site ID	Location Calder Highway / Freeway	Treatment and Seal size	Observations
	4I	217-218Km	SAM 14mm Seal	14mm seal over audio tactiles *Medium to Poor*
	4J	228.1-228.9Km	7mm Seal	7mm seal over audio tactiles *Reasonable*
	4K	321.1-327.8Km	14mm Seal	14mm seal over audio tactiles *Medium to Poor*
5. Sites where ATELM sealed over and new ATELM placed	5A	Midland Highway 86-87Km, north of Castlemaine	14/7 Geotextile seal	Old tactile line marking not removed, new audio tactile markings reinstated after treatment. *Reasonable*
6. Sites where reseal placed adjacent to ATELM	6A	267.2Km	Sealing both sides of ATELM attempt to abut up to the tactile ledge line	The existing tactiles were in reasonable condition, they have been painted. *Reasonable*
7. Sites where ATELM removed and replaced after sealing				No sites found that meet this criteria on the Calder Highway / Freeway
8. Sites with damaged ATELM	8B	230Km North of Wedderburn		Although there has been some loss of the ATELM the response was found to be *Reasonable*
9. Other Sites	9B	134.7-134.8Km	Around curve ATELM	Some ATELM has been damaged by trucks *Reasonable*
	9C	240Km	Just prior to 240Km old ATELM.	left hand side ATELM ineffective *Medium*
	9D	267.2Km	Seal is over the ATELM, all through lanes and shoulders.	Repainted edge line does not line up with the original ATELM. *Reasonable*

Criteria	Site ID	Location Calder Highway / Freeway	Treatment and Seal size	Observations
	9E	268.1	Running lanes are now 14mm Seal, 7mm shoulder reseal.	Both shoulders have been resealed onto the running lanes over the ATELM. *Reasonable*

Footnote: ***reasonable***. a similar audio response to new ATELM; ***medium*** reduced audio and vibration response, marginally acceptable, ***poor*** little or no audio and vibration responses, not desirable.

4. Testing Program

The subjective test method adopted for this project to evaluate the effectiveness of the audio tactile edge line marking was to conduct in-vehicle noise assessment, utilising a standard test vehicle, typically driven by the public.

The vehicles used were fleet vehicles currently available to GeoPave, being a Holden Commodore station wagon and Ford Falcon station wagon.

The subjective test involved setting the vehicles' radio to suit driver comfort and then driving onto the audio tactile edge line marking, noting the in cabin noise level changes, The rear vision mirror was used to assess the vibration levels generated by the ATELM and general awareness of the responses generated. Outcomes were thus based solely on the driver's perceptions for each site.

The characteristics of the ATELM and the maintenance treatments were categorised into the following groupings; ***reasonable***. a similar audio response to new ATELM; ***medium*** reduced audio and vibration response, marginally acceptable, ***poor*** little or no audio and vibration responses, not desirable.

Based on the subjective testing regime and the results obtained it was assessed that a more detailed audio metric program was not warranted.

5. Discussion and Outcomes

"Old" ATELM, even if there is some flattening, cracking and spalling of individual bars the combined audio edge line can still provide good audio and vibration responses. The testing program found that these older ATELM exhibited the categories of reasonable, medium, and poor audio and vibration responses depended on the extent of loss of the physical characteristics and the number of individual bar lost in any section of the ATELM. The standard dimensions of the ATELM were; bars 150mm long, 50mm wide, and 8mm high at 200mm spacing.

Ultimate life of the ATELM still has not been reached with some of the sites assessed approaching 10 years old. The assumed field life of 4 years, (Woolley 2006) therefore appears conservative.

Thus cost benefit analysis based on the shorter life could now also be considered conservative. Currently life cycle of ATELM could be described as follows:

- Road pavement surfacing rehabilitated as part of a periodic maintenance program; and the installation of the audio tactile edge line marking, (expected life 10 years);
- Resealing program, including sealing over the ATELM, (expected life 10 years).

Therefore it could be considered that at the end of this 20 year life cycle the reinstatement of ATELM should form part of any rehabilitation or periodic maintenance program.

Generally ATELM has been installed in accordance with the specified requirements, ie 200mm spacing, bar length 150mm, 50mm wide and 8mm high. However during the course of the desk top study a small number of sites were found that deviated from the standard. Figs 1 & 2 provide some examples. It is not known whether this installation was the accepted ATELM or whether this is poor placement of the ATELM. These sites did provide poor audio and vibration responses.

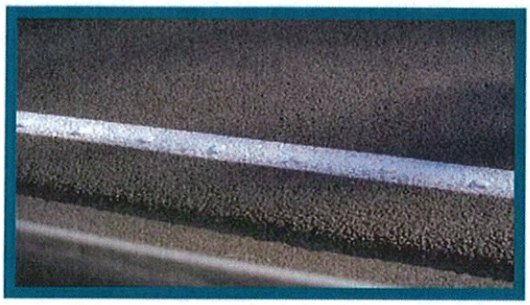


Fig 1

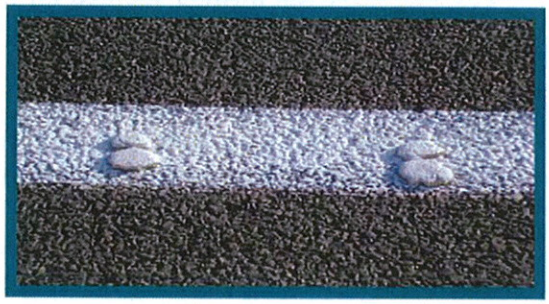


Fig.2

Audio Tactile Edge Line Marking not meeting Specification

It is recommended that should these issues arise they are addressed if specified correctly in the Contract during the defects liability period, ensuring that the effectiveness of the ATELM installation is as expected by VicRoads and the travelling public.

Sites where a 7mm seal was placed over the existing ATELM during a reseal program, audio and vibration responses were assessed as reasonable.(e.g. Sites 4E, 4Fand 4J). See Fig 3 & 4 for examples.

Fig 3

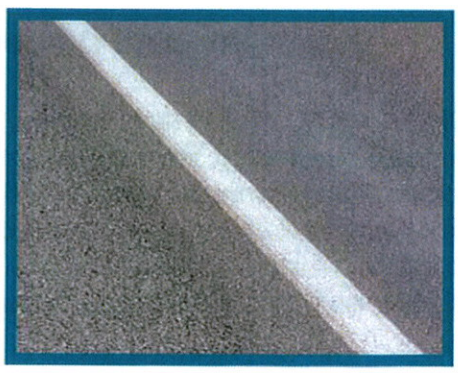


Fig 4

Sites with a 7mm seal over the ATELM

The ATELM bars were still visible after the sealing program and subsequent painted edge line markings.
Sites with 7mm seals provided reasonable audio and vibration responses. It is suggested that shoulder reseals using 7mm aggregate and sealing over the ATELM approx 50 to100mm into the running lane is considered a good option particularly in maintaining the audio and vibration characteristics of the existing ATELM.

When a 10mm seal has been selected the ATELM tends to be "buried" by the treatment and on some sites the audio and vibration response were reduced to the poor level. There were sites where the audio and vibration could be considered to be "medium" after placing the 10mm seal. This was attributed to the condition of the ATELM prior to the reseal and the size and shape of the 10mm aggregate used for the spray sealing treatment.

The sites that had a geotextile reinforced seal (e.g. Geotextile 14/7mm seal), the fabric tended to bridge the ATELM bars, see Fig 5& 6. There was some breaking of the seal and geotextile "bridging" the underlying tactile bars.

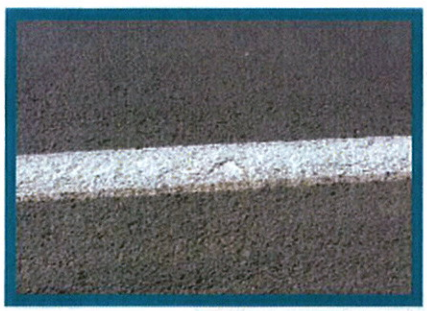


Fig 5

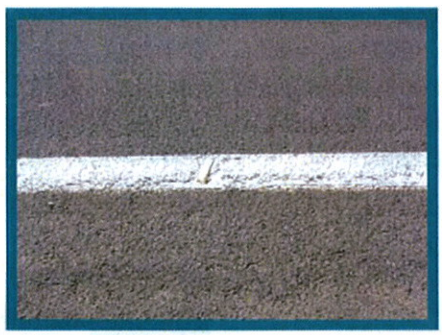


Fig 6

Geotextile and 14/7mm seal

It is recommended that when this treatment is being proposed that the ATELM be removed and replaced. This "bridging" effect did reduce the observed audio and vibration response, into the poor category.

Consideration was also given to extending the width of the running lane seal over the ATELM and onto the shoulder by 50-100mm. In older constructed pavements this would "bridge" the structural joint between pavement depths (shoulder, running lane). Costs associated with this maintenance approach would be higher, larger area being covered by including some of the shoulder, and the larger aggregate would significantly reduce the audio and vibration response of the ATELM, requiring the reinstatement of the ATELM after sealing.

Some ATELM reinstatement works are of dubious quality and some observations of maintenance works are shown in Figs 7 and 8.

Fig 7
Intermediate reinstatement

Fig 8
ATELM not removed or relocated

It is recommended that care should be taken when reinstating ATELM so that bars are reinstated rather than additional intermediate bars being generated, see Fig 7. Care should also be taken when reinstating or relocating ATELM to avoid mixed or confusing information to the road users, see Fig 8.

When undertaking reinstatement of ATELM works, the limits of the treatment can be assessed by a "drive test" and joints where previous works were undertaken, as shown in Fig.9, can be determined.

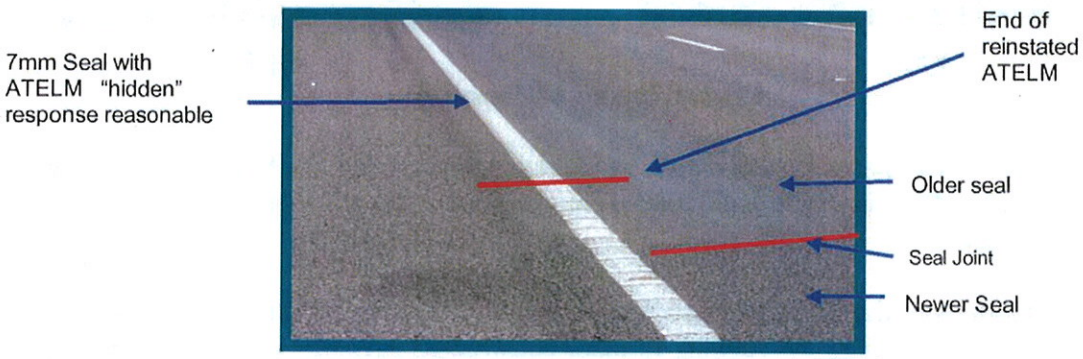


Fig 9
Audio Tactile reinstatement after sealing

5.1 The Selection Process

Visual assessment may not always be adequate to fully assess the existing ATELM limits, for example, Fig 9 above, gives the impression that the ATELM stops at the end of the reinstatement, but in fact the ATELM continues, "hidden" by the seal.

A "drive" test can provide a better insight into the limits of any reinstatement requirements and the performance of the existing ATELM, the driver noting the approach and departure characteristics, audio and vibration, from the proposed treatment site.

This subjective test:

- Can be very noisy exercise, for a short duration;
- Is probably needed prior to and after resealing works to confirm outcomes; and
- Can be used to determine the extent of ATELM reinstatement required.

Sealing joints between the shoulder and the running lane should not coincide with the ATELM. Good practice should dictate that any proposed joint should be 50-100mm clear of the ATELM bars.

6. Conclusions

This report on the "Management of Audio Tactile Edge Line Markings" (ATELM) has found that when carrying out reseals:

- 7mm seals, over the ATELM will provide a reasonable audio and vibration response;
- 10mm seals, will provide a medium response and thus this treatment is considered marginal and reinstatement of the ATELM is recommended;
- 14mm seals, poor response, treatment considered not desirable, reinstatement of the audio tactiles or a review of the treatment selected; and
- Geotextile seals, (similar to 14mm seals), over the ATELM will provide poor audio and vibration responses and removal and reinstatement of the audio tactile edge line marking is considered appropriate.

This outcome is based on the preface that one of the primary considerations is the preservation of the audio tactile line marking (ATELM).

If it is considered that the audio tactile edge line marking are worth preserving then the following actions will assist in meeting this objective;

(a) Limits of the sealing can be set to ensure that the performance of the ATELM is not compromised, for example:

- Shoulder reseals (usually 7mm) could extend across the ATELM into the running lane by 50-100mm, followed by repainting of the edge line, and
- Slow lane and or running lane reseals should terminate 50-100mm from the ATELM

(b) Project development and the assessment of treatments should include a commentary of the proposed impacts and layout to the current ATELM. A drive test of the ATELM to assess the current audio and vibration characteristics should be undertaken as part of this assessment.

(c) New installations of ATELM do not need to have the edge line painted; the reflectivity provided by the thermoplastic bars and glass beads is very high. ATELM should only be painted when the reflectivity has fallen below the designated intervention level.

(d) When reinstating the ATELM care should be taken to ensure that the existing bars are reinstated, rather than additional intermediate bars being generated. The reduction of spacing will usually increase the level of audio and vibratory response, (Ford, 1993). This increase maybe acceptable if there are no residential dwellings, near or adjacent to the treated area.

(e) Sealing joints between the shoulder and the running lane should not coincide with the ATELM. It is good practice to ensure any joints are clear of the proposed installation of ATELM, minimising risks of tactile bars debonding from the underlying surface.

(f) When using geotextile based treatments it appears good practice that the ATELM be removed prior to and replaced after sealing. This will ensure that bridging does not become an issue and subsequent loss of audio and vibration responses.

(g) After a reseal to ensure that the treatment has not adversely affected the functionality of the ATELM a "drive test" of the finished product will assist in confirming the audio and vibration response.

7. Recommendations

It is recommended that:

1. During project development and the assessment of treatments include a commentary of the proposed impacts and layout to the current ATELM. A drive test of the ATELM to assess the current audio and vibration characteristics should be undertaken and corrective actions in the scope of the project, such as remedial treatments proposed to the ATELM should be noted.
2. The proposed use of one 7mm seal over the ATELM is adopted in accordance with, Attachment 1, Mid-term Pavement Rehabilitation over existing Audio Tactile Line Marking. This recommended practice is widely circulated to Program Delivery Managers and Program Development Managers throughout Victoria, as part of a RSM guideline.
3. The findings of this R&D project will be disseminated to Regions, Projects and appropriate VicRoads staff.

8. References

1. Ernest Selvadurai, Oct-Nov 2004, Contract 5844 Defects in Profiled Line marking, VicRoads Western Region, Victoria.
2. Evan Ramsey, ARRB May 1999, RC90200
   Noise Generation Characteristics of Non-Standard Profile Edge Lining. ARRB Victoria
3. David Ford, 25 March 1993, Report No.28B0231.
   Tactile Edge Markings, Calder Highway Bendigo, Noise Investigation, VicRoads Materials Technology Dept, Kew Victoria
4. David Ford,20 December 1993, Report No.38B0039
   Tactile Edgeline Trials, South Gippsland Highway, Cranbourne, Environmental Noise Investigation, VicRoads Materials Technology Dept., Kew Victoria
5. David Ford, 19 December 1996, Report No.68B0042
   Edge Line Audible Markers, Hume Freeway Trial, Environmental Noise Measurements, VicRoads Materials Technology Dept. Kew Victoria
6. Peter Cairney, ARRB, February 1994, Report No. WD RS 94/001
   The Effect of Profile Linemarking on in Vehicle Noise Levels. ARRB Victoria.
7. Peter Cairney & Tan Hee-Wee, ARRB, December 1996, Report No. CR OC 4776
   Contract Report: Audio-Tactile Linemarking, Queensland Transport, ARRB Victoria.
8. D Munster, D Wong-Toi, M Owen, and V Dravitzki, ARRB, Rumble Strips-Development of Guidelines For Their Use in New Zealand, Transport Research Conference, 19th 1998, Sydney.
9. JE Woolley and AJ McLean, August 2006, Report No.CASR025
   Centre for Automotive Safety Research, Edge Delineations. The University of Adelaide South Australia.

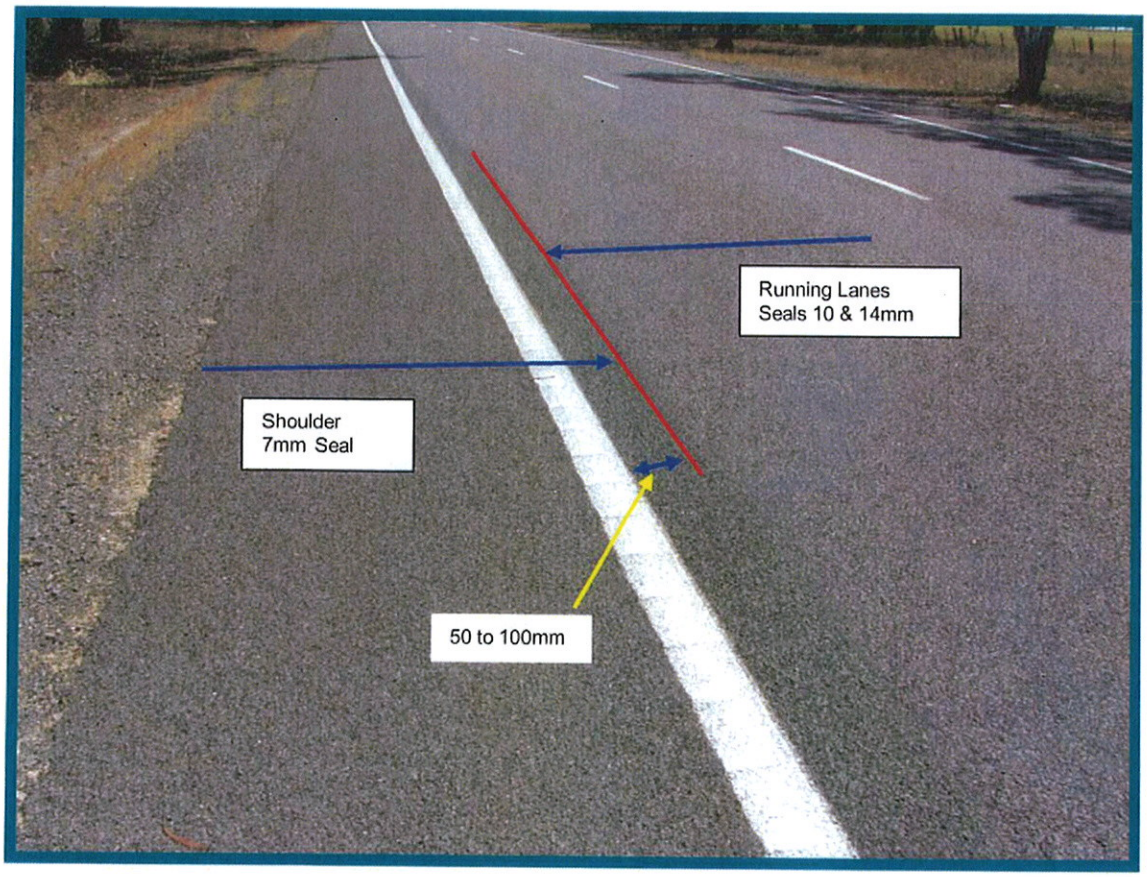
9. Attachments

Attachment 1

Title Mid-term Pavement Rehabilitation Over Existing Audio Tactile Line Marking

Attachment 1

Mid-term Pavement Rehabilitation over Existing Audio Tactile Line Marking



Recommended Practice.

Shoulder Reseals 7mm extending across the audio tactile line marking by 50 to 100mm.
Repainting of the edge lines.

Slow lane / running lane reseals shall terminate 50 to 100mm prior to the audio tactile edge line.