HTC Infrastructure Management Ltd.

VALIDATION OF ROMDAS TRANSVERSE PROFILE LOGGER

Report F003/1

19 December 2000

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Quality Assurance Statement	
File: F003/1	**Prepared by:** C.R. Bennett
Report Name: Validation of ROMDAS Transverse Profile Logger	**Reviewed by:** P. Hunter
Version: 1.0	**Approved for issue by:** C.R. Bennett
Date of Issue: 19 December	**Project manager:** C.R. Bennett
File Name: C:\Files\F - ROMDAS R&D\003 - TPL\F003-1 Validation Using Chile Data\F003-1 Validation of ROMDAS TPL.doc	

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REVISIONS

Revision	Date	Section/Page	Description

CONTENTS

VALIDATION OF ROMDAS TPL

1. INTRODUCTION

Overview

A ROMDAS Transverse Profile Logger (TPL) was supplied by HTC to APSA Ltd. of Chile in November 2000. APSA undertook a study which compared the ROMDAS TPL measurements to those from a 2.0 m straight-edge and wedge. This memo describes the analysis of the data as provided to HTC by APSA.

2. DATA PROCESSING

Data Processing

The data was processed using the ROMDAS algorithms. It was found that there was an error in the datum level coding which is designed to compensate for the sensors not being perfectly horizontal. This error was corrected and the results presented here are with the updated release (5.3a Build 5).

Calculating Rut Depth

ROMDAS contains two methods for calculating the rut depth:

- **Straight-edge Simulation**. This simulates a user-defined straight edge being placed across the transverse profile. The rut depth is calculated for the two wheelpaths separately.
- **Pseudo-rut**. This is calculated as the average difference between the high and low points in the profile.

The analysis here concentrated on the straight-edge since this was compatible with the way in which the field data were collected, but the pseudo-rut calculations were also investigated.

Full details on the algorithm for calculating rut depths are given in the ROMDAS manual.

The data were processed and analysed in Microsoft Excel.

3. EVALUATION OF STRAIGHT-EDGE RUT DEPTHS

Overview

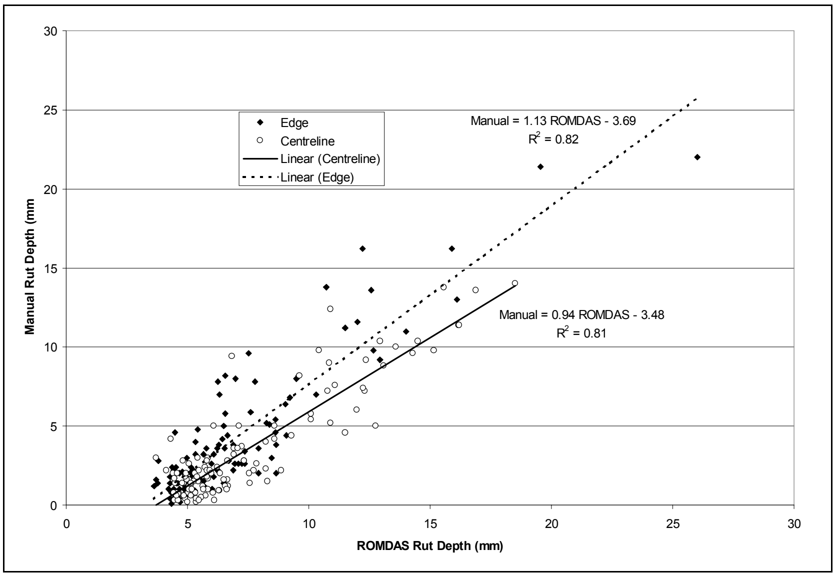
The rut depths were available for the left and right wheelpaths. The manual data were usually at 10 m intervals, although some were at 5 m and some at 15 m. The ROMDAS data were recorded at 5 m intervals.

The data were averaged to obtain the average rut depth at 100 m intervals. This was used as the basis for the comparison.

Rut Depth Bias

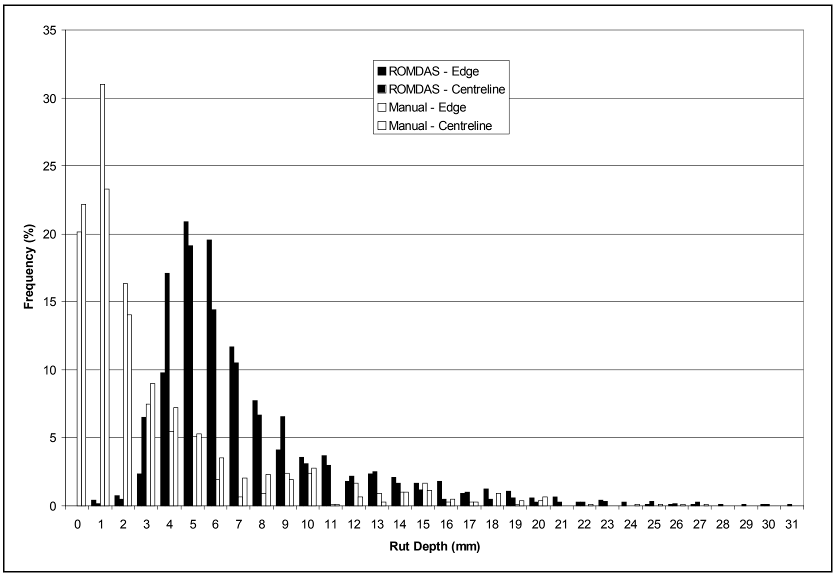
It had been noted in a previous network survey that there was an apparent bias of approximately 3 mm in the ROMDAS rut measurements. This could be due to a texture effect or possibly the way in which the rut depth measurements are staggered over a 2 m interval when ultrasonics are fired.

To investigate this, the manual and ROMDAS rut depths for each wheelpath were plotted and a regression made of the data. The results are shown in the figure below.



ROMDAS vs Manual Rut Depths

During the surveys the minimum 5 m interval rut depths recorded by ROMDAS were 0.4 mm and 0.7 mm. However, as the histogram below shows, there were few readings below 3 mm while there were a large number of manual readings of 0 – 1 mm. Both the histograms follow the expected lognormal distribution for the data.



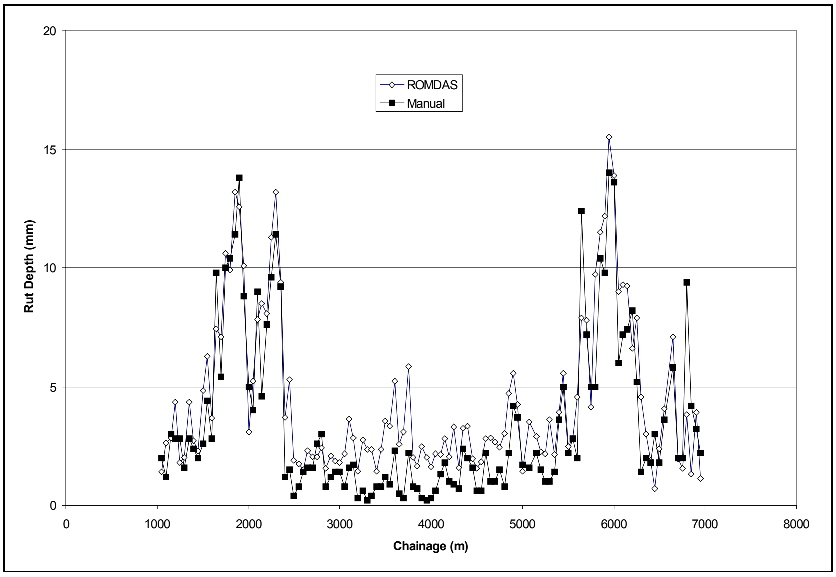
Histogram of ROMDAS Rut Depth Distribution

On the basis of the above there is a *prima facie* case for there being a bias in the measurements when compared to manual rut depth measurements. However, it needs to be appreciated that this may also be due to an inability of the manual method to measure small rut depths accurately. Since the precision of the manual measurements was to the nearest integer, at least part of the bias may be due to the measurement technique.

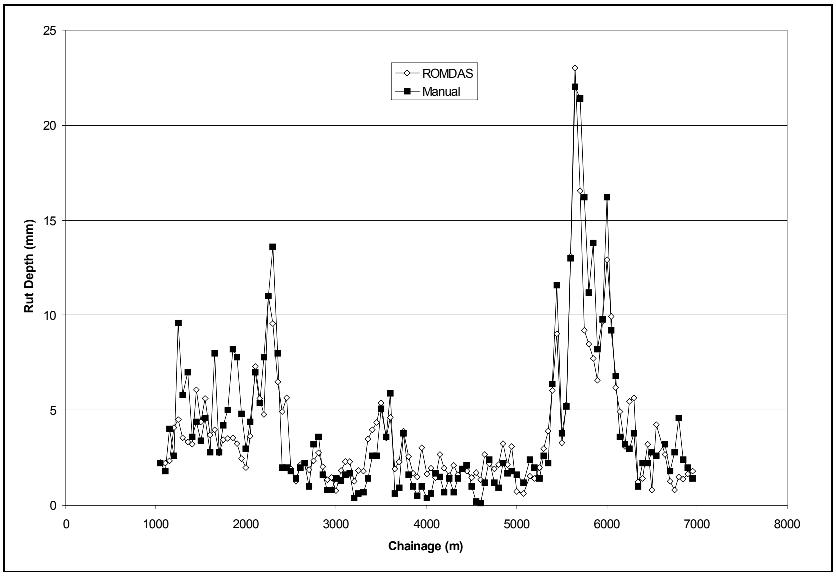
The above argument aside there does appear to be a need to correct for the bias in the ROMDAS measurements and subtracting a constant of 3 mm from the calculated rut depth would achieve this. To allow for flexibility, it is proposed to include the facility in Build 6 of a linear regression to correct for bias texture effects.

Rut Depth Profiles

The figures below show the rut depth profiles over distance from ROMDAS and the manual data. These were calculated using the 3 mm bias correction factor proposed above.



Rut Depth Profile – Centreline

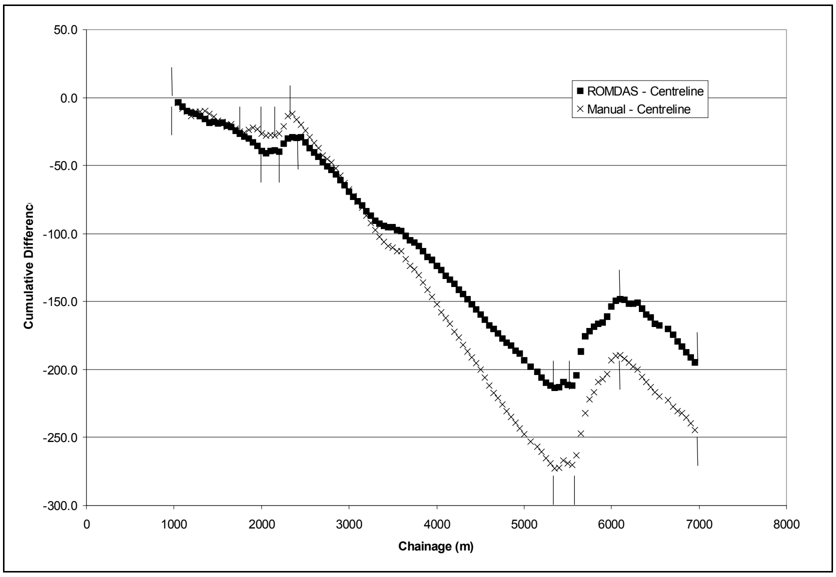


Rut Depth Profile – Edge

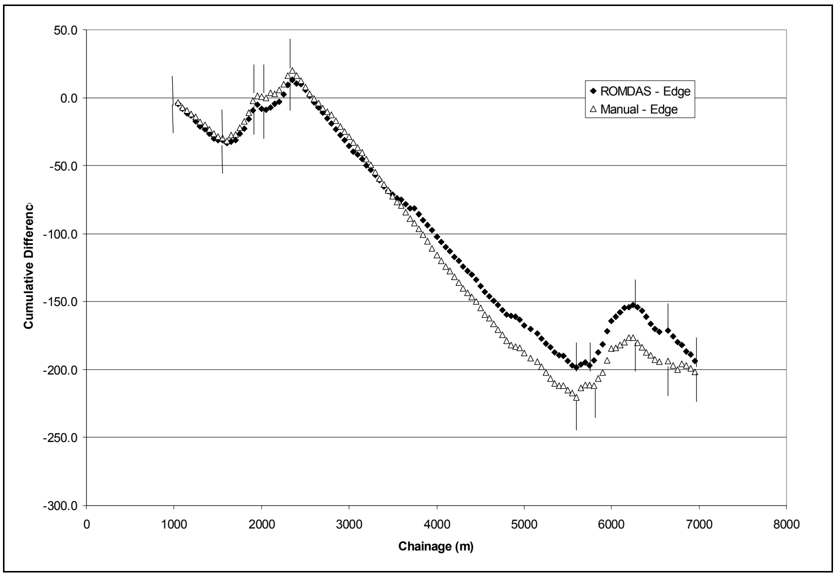
The data from these profiles show that ROMDAS was able to accurately identify those sections of the road with rutting. Where there are differences this could be due to the different sampling intervals used between the manual and automated ROMDAS measurements.

Section Rut Depths

The end purpose of measuring rut depths is to identify sections of road which require remedial treatments due to rut depth and to quantify the magnitude of the rut depths on these sections. To investigate the suitability of the ROMDAS measurements the manual and ROMDAS measurements were analysed to create homogeneous sections using the cumulative deviation (difference) method (see Annex A). The figures below show the homogenous sections (represented by the vertical bars) using this method.

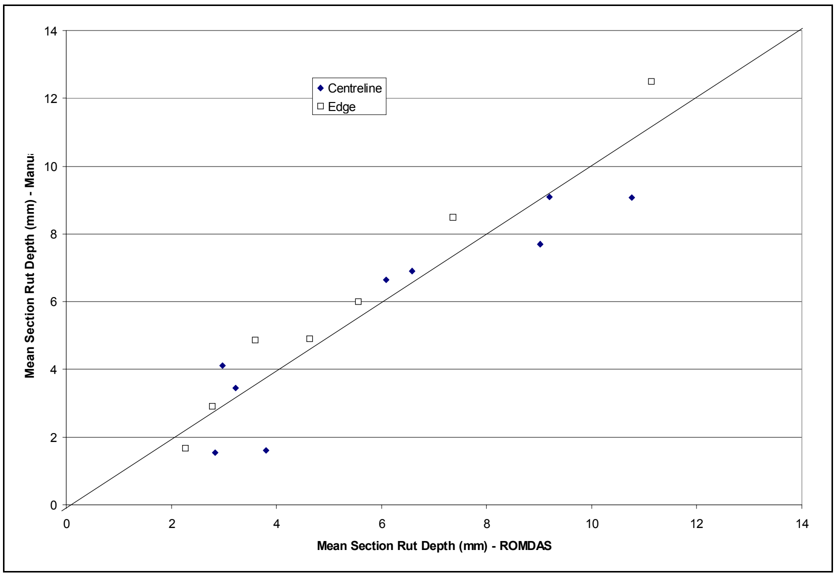


Sectioning – Centreline Data



Sectioning – Edge Data

For each of the sections identified using the cumulative difference method the average rut depth was calculated. As shown in the figure below, there was a good agreement between the manual and ROMDAS rut depths (R^2 = 0.98 for Centreline; 0.86 for Edge).



Section Average Rut Depths

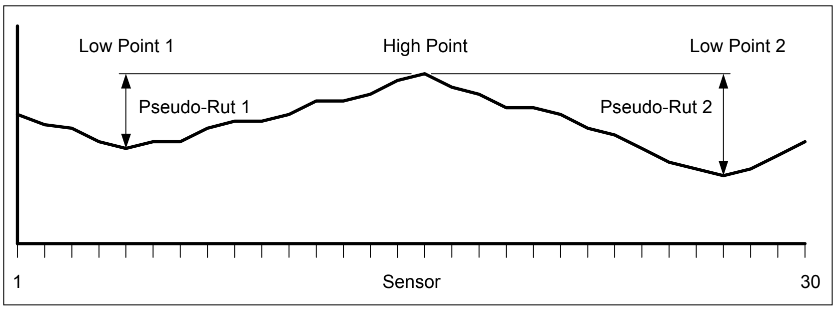
This analysis confirms two key points:

- The ROMDAS TPL rut depth measurements will result the same sections for treatment as would arise with manual measurements.
- The mean rut depths from the ROMDAS TPL will correspond to those from the manual method for the purpose of treatment design.

4. EVALUATION OF PSEUDO-RUT DEPTHS

Overview

As illustrated below, pseudo ruts are the difference between the high and low point in each wheelpath. This is a useful measure when only a portion of the rut bar is used—for example just the 2 m main section

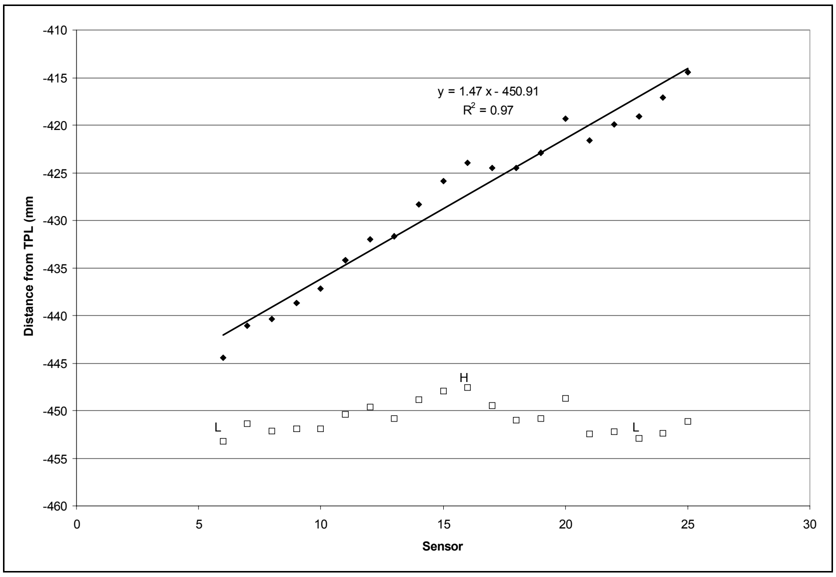


Definition of Pseudo-Ruts

Algorithm

The existing algorithm was developed by ARRB Transport Research for a project in Indonesia where it was not possible to use the TPL with the wings extended due to operational difficulties on narrow roads. However, the algorithm does not consider the orientation of the vehicle to the road and this reduces its accuracy.

The importance of this can be viewed from the figure below. This shows the TPL measurements and how there is a difference of 30 mm between sensors 6 and 25. The regression line fitted to these data give the angle of the bar to the road (see the ROMDAS manual with the discussion of measuring crossfall for further details).



Pseudo-Rut Measurements

If the data are corrected using the slope of the regression line it is reoriented to the lower set of data. This also shows the low and high points for the pseudo-rut calculations.

This change to the algorithm will result in an improvement to the accuracy of the pseudo-rut measurements.

5. CONCLUSIONS

Conclusions

This analysis has confirmed that the ROMDAS Transverse Profile Logger (TPL) gives measurements which are consistent with those from manual rut depth surveys. When rut depth profiles along a road are analysed it results in almost identical sections to which would have arisen with manual methods, and the mean rut depth on these sections are consistent.

It is proposed to make two changes to the ROMDAS data processing routines: the inclusion of a bias correction factor to account for texture or measurement biases and a change to the pseudo-rut calculations to correct for the orientation of the TPL to the road surface.

ANNEX A: SECTIONING USING CUMULATIVE DEVIATION

Principle

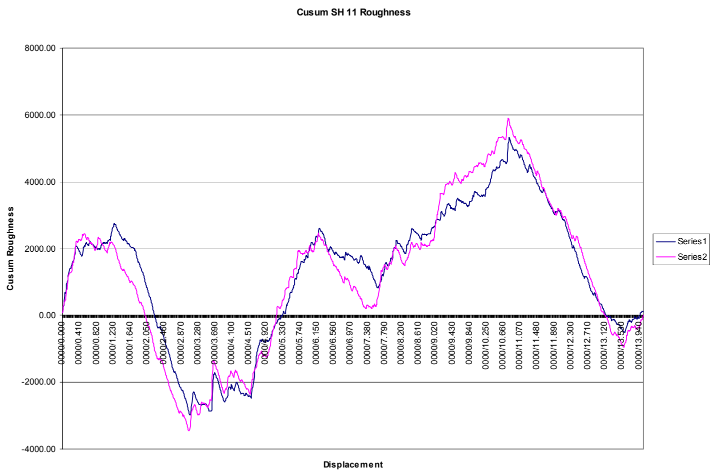
The cumulative deviation of the attribute from a target level is established and plotted. The user can then highlight points where the direction of the cumsum changes to create sections.

Calculations

1. The user defines the attribute of interest (*e.g.* roughness).
2. The user defines the statistic to use as the cusum target (*e.g.* mean, mean + 0.5 standard deviations).
3. For each measurement, the cusum is calculated as: $\sum$ (attribute - target). An example is given in the table below where the mean is the target.

		meanleft	88.69
		meanright	91.38
		stdleft	45.48
		stdright	48.44
naasra_left	**naasra_right**	Cusum Left	Cusum Right
171	168	82.31	76.62
171	210	164.62	153.23
171	162	246.94	271.85
202	130	329.25	342.47
233	120	442.56	381.08
184	131	586.87	409.70
81	115	682.18	449.31
76	141	674.49	472.93
192	251	661.81	522.55
266	160	765.12	682.16
131	129	942.43	750.78
120	156	984.74	788.40
121	294	1016.05	853.01
224	155	1048.36	1055.63

4. The chart below is an example of the cusum plot. Where there is a change in direction it indicates a change in condition. When the slope is upwards the road is worse than average; level it is average; downwards it is better than average.



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