UNSEALED ROAD CONDITION RATING SYSTEM FOR RAMM

LITERATURE REVIEW

Transit New Zealand Research Report No. 52

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PO Box 5084, Lambton Quay, Wellington, New Zealand
Telephone (04) 499-6600; Facsimile (04) 496-6666

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CONTENTS

LIST OF ABBREVIATIONS

AADT	Average Annual Daily Traffic
ADT	Average Daily Traffic
ARR	Australian Research Report
ARRB	Australian Road Research Board (now ARRB Transport Research Ltd)
ASTM	American Society for Testing Materials
AUSTROADS	National Association of Road Transport & Traffic Authorities in Australia
BMI	Betterment Maintenance Index
CRREL	Cold Regions Research and Engineering Laboratory
DC	District of Columbia, USA
DOT	Department of Transport, UK
DVI	Detailed Visual Inspection
DWK	Duffill Watts & King Ltd, Dunedin, NZ
FNDC	Far North District Council, Northland, NZ
GST	Goods and Services Tax
IRRD	International Road Research Documentation
ISSN	International Standard Serials Number
ISBN	International Standard Book Number
McTrans	Transportation Research Centre of the University of Florida, USA
MDS	Maintenance and Design System
MOT	Ministry of Transport and Communication, Canada
NAASRA	National Association of Australian State Roading Authorities
NITRR	National Institute for Transportation and Road Research , SA
NTIS	National Technical Information Service, USA
NZ	New Zealand
OECD	Organisation for Economic Co-operation and Development
PCR	Pavement Condition Rating
PIARC	Permanent International Association of Road Congresses
PMS	Pavement Management System
RAMM	Road Assessment and Maintenance Management
RCRS	Road Condition Rating System
RCS	Road Condition Survey
RMI	Re-gravelling Maintenance Index
ROAD	Database for ARRB (Australia)
RTA	Roads and Traffic Authority, New South Wales, Australia
RWA	Finland Roads Administration
SA	South Africa
TDV	Total Deduct Value
TeLIS	Technical Library and Information Service, NZ
TNZ	Transit New Zealand
TRIS	Transportation Information Service, USA
TRB	Transportation Research Board, Washington DC, USA
TRL	Transport Research Board, UK (after 12/1991)
TRR	Transportation Research Record
TRRL	Transport and Road Research Laboratory, UK (until 12/1991)
UI	Urgency Index
UK	United Kingdom
URCI	Unsurfaced Road Condition Index
USA	United States of America
vpd	vehicles per day

EXECUTIVE SUMMARY

This review of unsealed road condition rating systems for use in RAMM (Road Assessment and Maintenance Management, the rating system used by Transit New Zealand) lists the results of a search of the international literature on the topic, carried out in 1993-94. It reviews the publications retrieved, with special emphasis on those which include either recording systems for unsealed road condition rating, or guidelines for using such systems.

The favoured systems (six in number) are ranked in order of applicability to New Zealand road conditions by comparison of the elements observed. Comments are made about the final uses of rating survey data and on the advisability of trialling any overseas system in competition with the system currently incorporated in the *"RAMM Standards and Guidelines Part II: Unsealed Road Condition Rating Standards"*, Issue I, May 1994. Data presented as a result of this research project might also assist in a future review of the RAMM manual.

Recommendations are made to:

- Retain Part II of the RAMM manual, with respect to inventory, sampling and methods of measurement.
- Include, in the RAMM manual Part II, the elements of dust and aggregate loss.
- Include, in the RAMM manual Part II, index numbers as outputs on all the elements to be assessed to enable prioritisation of works to be facilitated.

ABSTRACT

International literature on unsealed road condition rating systems was reviewed in 1993-94, with the objective of recommending to Transit New Zealand a system suitable for use on unsealed roads in New Zealand.

The present rating system used in New Zealand is the *"RAMM Standards and Guidelines Part II: Unsealed Road Condition Rating Standards"*, Issue 1, May 1994. This system, with some modifications, is recommended as still being appropriate for unsealed roads in New Zealand.

1. INTRODUCTION

1.1 Background

New Zealand's 93,000 km of roading network includes 82,000 km of local roads of which approximately 39,000 km (48%) are unsealed. This percentage of unsealed local roading indicates that many local road controlling authorities have jurisdiction of far greater lengths of unsealed roads than sealed roads.

Unsealed roads form an integral part of the economic and social fabric at both local and national levels. The levels of funding, maintenance and management inputs for such roads are based on use, climate, topography, materials, condition, role in the roading hierarchy, economics, local knowledge and experience. These factors combined provide a basis for deciding future maintenance strategies and treatments for unsealed roads.

Transit New Zealand's computer-based Road Assessment and Maintenance Management (RAMM) system allows for recording the condition, analysing the data and recommending maintenance treatments of roads. The original version (first issued in 1988) was only for sealed roads, and recorded only basic inventory data. It did not have provision for recording condition or treatment selection of unsealed roads.

The increasingly widespread use by local authorities of RAMM to support their decisions for maintenance strategies for sealed roads has raised interest in developing an unsealed road condition rating and treatment selection module for the existing RAMM system. Then in 1994 *RAMM Standards and Guidelines: Part II Unsealed Road Condition Rating Standards* (referred to hereafter as the RAMM manual) (Transit New Zealand 1994) was issued for unsealed roads.

1.2 Literature Review

The purpose of this research project is *"to identify by way of a search and review of the international literature, the applicability of existing overseas unsealed road condition recording systems to New Zealand roads with the objective of selecting systems worthy of further detailed investigation"*.

An initial international literature search was made early in 1993 for operational unsealed road condition rating systems used overseas. The systems that were retrieved and their applications to the New Zealand roading network are reviewed in this report.

Following the submission of an interim report in August 1993 and, based on the comments of the review team, a second search of additional library sources was undertaken in 1994. Seven new items were retrieved but only four were evaluated. Two items from the initial search were still not available.

More road condition recording systems were only proposals or guidelines than there were operational systems, although some of these overseas guidelines may have been adopted since the review.

Principal among the new items was Part II of the RAMM manual (Transit New Zealand 1994), which effectively has pre-empted the research reported in this literature review. Also obtained independently was the Hallett and Jacobson paper *"Pavement management systems for unsealed roads"*, presented at the 1994 NZ Land Transport Symposium, about the system used by the Far North District Council (FNDC), New Zealand.

Both these New Zealand systems are reviewed in Section 3 of this report because, although they do not strictly represent an *"overseas road condition recording system"*, they are clearly part of the international literature. Also they are most applicable to the project.

The development of maintenance strategies based upon the results of condition rating surveys was not considered in this stage of the research project. Nevertheless, the methods used, the elements measured, and the final outputs of the systems evaluated have significant effects on the immediate uses to which the road condition data may be put. Thus the immediate uses given for the recorded and filed data obtained from these measurements have also been noted in the evaluations.

The terminology and statements used in the original papers and manuals have been retained, and therefore inconsistencies in the use of some of the terms used in the reviews in Section 3 of this report may occur.

1.3 Objectives

The objectives of this project are to:

1. Identify and review existing and operating unsealed road condition rating systems.
2. Recommend the unsealed road condition rating systems appropriate to New Zealand roading requirements.

2. LITERATURE SEARCH

2.1 Search Terms

The following search terms were adopted for retrieving information and literature from the sources listed inn Section 2.2 of this report.

General Focus Terms:

- Unsurfaced Roads
- Unsealed Roads
- Unpaved Roads
- Gravel Roads
- Metal Roads

Specific Focus Terms:

- Rating/inspection/evaluation
- Serviceability measurement
- Performance indicators
- Condition rating/indices
- Defect measurement
- Maintenance strategy/planning
- Management systems

2.2 Search Facilities

The following search facilities were used to retrieve literature from national and international sources:

TeLIS

- Dynix
- Kiwinet
- Dialog

ARRB

- ROAD (the ARRB database)
- IRRD (International Road Research Documentation)
- TRIS (Transportation Information Service produced by the US Transportation Board)
- NTIS (US National Technical Information Service)

A second search was made in 1994 for which TeLIS and ARRB were asked to interrogate:

- McTrans (Transportation Research Centre of the University of Florida)
- TRL British Overseas Unit
- NITRR South Africa (particularly work by Paige-Green)
- New Zealand Literature

TeLIS retrieved nothing that was both fresh and relevant from their sources of databases NZ Bibliographic Network, Dynix and Kiwinet: BUSI, INDE, INNZ, NINX, NEWZ, STIX.

ARRB found nothing on this topic in McTrans, nothing fresh in TRIS, only pre-1985 material in TRL, and some useful material mainly from South Africa, in ROAD (Australia) and IRRD.

2.3 Literature Search Titles and Authors

The following Table 2.1 lists brief references (of author, date, title only) for the 37 publications retrieved using the search terms listed in Section 2.1 of this report, together with general comments about their usefulness.

The publications are evaluated in Section 3, Literature Review and Evaluation, of this report. The references are in two groups, those retrieved by the first search (References C1-C23, in alphabetical order), and those retrieved by the second search (References C24-C32).

Full references to all the retrieved publications are listed alphabetically in Section 7 of this report.

Table 2.1 List of publications retrieved by the literature search.

— Publication not evaluated.
C1, C2, etc. Reference numbers used in this report; publications are held at Transit New Zealand in *Transit New Zealand Research Project No. PR3-0088 Appendix C and Supplement.*
[2] Copy obtained and retained.
* Publication not received by 31 January 1995.

Reference	**Author. Date. Title of publication** (Reference in Section 7 of report)	**Comments** (Details of evaluation in Section 3 of report)
C1	ARRB. 1993. Unsealed roads manual: guidelines to good practice.	Pavement rating system guideline
C2	Chong, G.J., Wrong, G.A. 1989. Manual for condition rating of gravel surface roads.	A useful system worthy of a more detailed review, linked to treatment selection
C3	Eaton, R.A. 1988. Development of the unsurfaced roads rating methodology.	Introduction to Report 87-15 (Eaton et al. 1987a)
C4[2]	Eaton, R.A., Gerard, S. 1991. Results of unsurfaced road rating surveys.	Reviews the results of using Report 87-15 (Eaton et al. 1987a)
C5[2]	Eaton, R.A., Gerard, S., Cate, D.W. 1987a. Rating unsurfaced roads - a field manual for measuring maintenance problems.	Report 87-15, good system; complete data available; no treatment link
C6[2]	Eaton, R.A., Gerard, S., Cate, D.W. 1988. Rating unsurfaced roads.	See Report 87-15 (Eaton et al. 1987a)
C7[2]	Eaton, R.A., Gerard, S., Datillo, R.S. 1987b. A rating system for unsurfaced roads to be used in maintenance management.	See Report 87-15 (Eaton et al. 1987a)

Table 2.1 (continued)

Reference	**Author. Date. Title of publication** (Reference in Section 7 of report)	**Comments** (Details of evaluation in Section 3 of report)
C8[2]	Eaton, R.S., Gerard, S., Datillo, R.S. 1989a. A method for rating unsurfaced roads.	See Report 87-15 (Eaton et al. 1987a)
C9[2]	Eaton, R.S., Gerard, S., Datillo, R.S. 1989b. Method for rating unsurfaced roads.	Summary of Report 87-15 (Eaton et al. 1987a)
—	George, K.P. 1990. Pavement management information system (PMIS).	Not evaluated
C10[2]	Gerke, R.J., Tooma, G.G. 1990. Road pavement management - information needs of a roading authority.	Reports full Pavement Management System of RTA NSW; further information required
C11[2]	Hopwood, T.II, Sharpe, G.W., Hutchinson, J.W., Deen, R.C. 1987. Automated data requisition for low-volume road inventory and management.	Not relevant
C12[2]	Isotalo, J. 1987. Roads in developing regions. Report from Finland.	Includes a simple rating system; worth further study
C13[2]	Kennedy, C.K., Butler, I.C. 1990. Road assessment survey systems.	Reports use of mobile high speed measuring vehicles
—	Magnussen, G., Amberg, P.W., Petterson, H.E. Undated. The rating and measuring of road roughness on gravel roads.	In Swedish - not considered because of cost of translation
C14[2]	Männistö, V., Tapio, R. 1990. Maintenance management on gravel roads.	Rating system used in Finland
C15[2]	Mercier, C.R., Stoner, J.S. 1989. Road sufficiency rating system model validation.	Not relevant

Table 2.1 (continued)

Reference	**Author. Date. Title of publication** (Reference in Section 7 of report)	**Comments** (Details of evaluation in Section 3 of report)
C16[2]	Mulholland, P.J. 1991. Pavement management systems (PMS) for local government - guidelines report.	Guidelines to a complete PMS, including a rating system
C17[2]	OECD. 1990. Road monitoring for maintenance management. Vol.1 Manual for developing countries; Vol.2 Damage catalogue for developing countries.	Contains a useful system; worth further study
C18[2]	Riverson, J.D.N., Sinha, K.C., Scholer, C.F., Anderson, V.L. 1987. Evaluation of subjective rating of unpaved county roads in Indiana.	A study of a subjective rating system; includes useful pavement distress criteria
—	Riverson, J.D.N., Scholer, C.F., Middendorf, D. 1988. Road maintenance management information system for counties and cities.	Not evaluated
C19[2]	Sullivan, T., Scott, R. 1990. Strategic road network management - an approach using roughness.	Uses roughness as sole measurement; not an unsealed condition rating system specifically
C20*	Transportation Information Center. 1989. Gravel-PASER manual.	Not received by 31/1/95
C21	Visser, A.T., 1981. An evaluation of unpaved road performance and maintenance.	Maintenance and design system only - not fully relevant
C22*	Visser, A.T. 1985. Review of the use of maintenance and design systems for managing unpaved road networks.	Not received by 31/1/95
C23[2]	Walker, D.M. 1991. Evaluation and rating of gravel roads.	Awaiting Gravel-PASER manual (C20)
—	Wambold, J.C., Park, W.H., Hayhoer, G.F. 1982. Implementation of an automated rating procedure for pavement surface roughness.	Not considered to be relevant

Table 2.1 (continued)

Reference	**Author. Date. Title of publication** (Reference in Section 7 of report)	**Comments** (Details of evaluation in Section 3 of report)
—[2]	White, M.T., Metcalf, N.J. 1984. TARA system aid to highway maintenance planning.	Not considered to be relevant
C24[2]	Transit New Zealand. 1994. RAMM standards and guidelines. Part II: Unsealed road condition rating standards	Current New Zealand state highway practice
C25[2]	Hallett, J.E., Jacobson, P. 1994. Pavement management systems for unsealed roads.	Current operating system for Far North District, New Zealand
C26[2]	Department of Transport UK. 1992. National road maintenance condition survey.	Useful methodology
C27[2]	Beaven, P.J., Robinson, R., Aklilu, K. 1988. The performance of experimental weathered basalt gravel roads in Ethiopia.	Not relevant
C28[2]	Paige-Green, P. 1990. Some surface roughness, loss and slipperiness characteristics of unpaved roads.	Not relevant
C29[2]	Pienaar, P.A., Visser, A.T. 1992. The evaluation and prioritization of unpaved roads maintenance in developing areas.	Some useful element classification and assessment
C30[2]	Thompson, H.W., Rose, D.A., Fanner, S.M. 1989. Establishing priorities for upgrading of gravel roads.	Not relevant; economic basis only
C31[2]	Paige-Green, P., Netterberg, F. 1988. Towards acceptability criteria for unpaved roads.	No rating system; some useful notes on dust
C32[2]	AUSTROADS. 1987. A guide to the visual assessment of pavement condition.	Useful methodology and coding

3. LITERATURE REVIEW AND EVALUATION

3.1 Evaluated Publications

The publications listed in Table 2.1 that were obtained from the literature search are described in this Section. They are annotated and evaluated, specifically for their usefulness as condition rating systems that can be applied to unsealed roads in New Zealand. Each publication has a reference number, i.e. C1 to C32, which is used throughout the report.

The references for all the publications are given in full, in alphabetical order, in Section 7 of this report. A collection of copies of the publications received is kept on file at Transit New Zealand, as *Appendix C* and *Supplement to Transit New Zealand Research Project No. PR3-0088.*

Australian Road Research Board Limited (ARRB). 1993. *Unsealed roads manual: Guidelines to good practice.* ARRB Ltd, Victoria, Australia.

Reference C1*

Description

Section 6 of this ARRB manual offers an unsealed road condition rating methodology based on the AUSTROADS (formerly NAASRA, 1987) document *"A guide to the visual assessment of pavement condition".*

The system relies on road inventory data based on "links" or road sections similar to those used in RAMM. Start and finish positions are recorded along with road structure (physical elements), traffic, physical features and topography.

The assessment of the condition of each road link (section) can be based on:

- Visible defects such as corrugations, ruts etc.
- Life of the pavement measured by gravel thickness.
- The effectiveness of the drainage system.
- Geometric design features.
- Road safety features.

Methodology

The Road Condition Rating System (RCRS) is a tool to quantify, through the use of rating indices, the assessment of the road link condition. It is suggested that the system is introduced in levels so that only essential information is collected and matched to the resources available to collect it.

- Level 1 and Level 2 describe establishing the inventory and some base condition data such as safe speed. Comparing safe speed with design speed is suggested as a possible sole criterion for condition rating in remote areas.

- Level 3 introduces criteria such as ride quality and suggests roughness measurements.

- Level 4 suggests monitoring the severity and extent of defects. The manual lists headings for defect rating as:
  - Deformation
  - Corrugations
  - Rutting
  - Shoving
  - Potholes
  - Water table drains
  - Safety features

Severity of these defects is rated as slight, moderate and severe based on the percentage area affected or other criteria for drainage and safety.

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*C1, C2, etc. Reference number used in this report.

Discussion

This manual outlines guidelines for establishing an unsealed road performance management system which includes road condition rating. It could be used either as a guide to evaluate existing systems or as a base to establish a generic system.

Conclusions

While useful guidelines are included for establishing an unsealed road condition rating system, the paucity of detail and procedure is such that considerable development would be required to implement this system on its own.

Chong, G.J., Wrong, G.A. 1989. ***Manual for condition rating of gravel surface roads.*** **Research and Development Branch, Ministry of Transportation of Ontario, Canada.**
Reference C2

Description
In Ontario 50% of the total road length is unsurfaced but no system had been designed to address the unique performance pattern of gravel surface roads. This document was prepared to meet this need and to present a roadway condition rating system for gravel surface roads.

While rating paved surfaces is based on:
- riding quality, and
- extent and severity of roadway distress manifestations,

rating unsurfaced roads in Ontario is based only on the latter, because riding qualities of unsurfaced roads
- are directly related to distress manifestations,
- can change with inclement weather rapidly,
- can change periodically depending upon grading policy.

Methodology
The rating methodology comprises two elements:

(a) The field measurement, rating and treatment recommendations relating to individual or combinations of manifestations of pavement and road shoulder distress.

(b) An assessment of the overall pavement performance using a subjectively derived rating number describing the level of serviceability based on the evaluation of surface distress carried out under (a) above. The rating number triggers suggested maintenance actions.

Under (a) above, distress manifestations are grouped under three main headings:

- Roadway surface defects
- Roadway surface deformation
- Shoulder distress manifestation

Each of these three headings are subdivided as follows:

- Roadway Surface Defects
  - Loose gravel
  - Dust
  - Potholes
  - Breakup

- Roadway Surface Deformation
  - Washboard (corrugations)
  - Rutting
  - Flat or reverse crown
  - Distortion (depressions, shoving, frost heave, etc.)

- Shoulder Distress Manifestation
  - Excessive height
  - Ponding
  - Overgrowth

Each is then evaluated by Severity and Density, using objective criteria.
Examples given of distress manifestation gradings for severity and density (or extent) are:
- Severity – Slight, Moderate, Severe
- Density – Intermittent, Frequent, Extensive

Pavement Condition rating is recommended to be undertaken (in Ontario) in their late spring while the effects of frost action are still visible, otherwise in mid-summer. Preferred cycle is one year but the maximum interval is three years.

Procedure
Steps to be undertaken are to:
- Establish evaluation sections: maximum length 1.6 km on rural roads, and between intersections for urban roads.

- Assess distress manifestations on evaluation section by driving over at 50 km/h on rural, 30 km/h on urban roads, but stop to inspect.

- Assess "Dust" distress at posted speed.

- Complete "Gravel Surface Pavement Condition Evaluation Form", Figure A-1 (reproduced on p.22 of this report).

- Assign Pavement Condition Rating (PCR) in accordance with guidelines given in Table B-1 (reproduced on p.23 of this report).

Detail
While severity is described in detail for each distress type, density is typically defined as:
- Intermittent < 20% of surface affected
- Frequent 20-50% of surface affected
- Extensive > 50% of surface affected

Ministry of Transportation Ontario

GRAVEL SURFACE PAVEMENT CONDITION EVALUATION FORM

Location From: _____ To: _____

LHRS [ ][ ][ ][ ][ ] BEGINS [ ][ ][.][ ] km OFFSET

Section Length [ ][ ][.][ ] km LENGTH

District [ ][ ]

Highway [ ][ ][ ][ ]

Survey Date [ ][ ] YEAR [ ][ ] MONTH

PCR [ ][ ][ ]

Traffic Direction [ ] B : BOTH DIRECTIONS; N : NORTH BOUND; S : SOUTH BOUND; E : EAST BOUND; W : WEST BOUND

Contract No. [ ][ ] – [ ][ ][ ]

WP No. [ ][ ][ ][ ] – [ ][ ] – [ ][ ][ ]

Roadway Surface Distress Manifestation			SEVERITY OF DISTRESS			DENSITY OF DISTRESS Extent of Occurrence,%		
			Slight	Moderate	Severe	Intermittent	Frequent	Extensive
			1	2	3	< 20	20-50	> 50
			1	2	3	1	2	3
SURFACE DEFECTS	Loose Gravel	1						
	Dust	2						
	Potholes	3						
	Breakup	4						
SURFACE DEFORMATION	Washboard	5						
	Rutting	6						
	Flat / Reverse Crown	7						
	Distortion	8						

Shoulder Distress Manifestation	SEVERITY OF DISTRESS						DENSITY OF DISTRESS Extent of Occurrence,%					
	Right			Left			Right			Left		
	Slight	Moderate	Severe	Slight	Moderate	Severe	Intermittent	Frequent	Extensive	Intermittent	Frequent	Extensive
	1	2	3	1	2	3	< 20	20-50	> 50	< 20	20-50	> 50
							1	2	3	1	2	3
EXCESSIVE HEIGHT												
PONDING												
OVERGROWTH												

Distress Comments (Items not covered above) _____

Suggested Maintenance Treatment: _____

Evaluated by: _____

Figure A-1/ Gravel Surface Pavement Condition Evaluation Form

(as reproduced from Chong and Wrong 1989)

Table B-1

A Guide for the Estimation of Pavement Condition Rating and Suggested Maintenance or Rehabilitation for Gravel Surface Roads

Roadway surface well shaped with well defined shoulder between roundings. No surface distress manifestations, just a "slight" classification for dust and loose gravel. No frost heave or soft spots when evaluation is made in late spring. Good drainage for surface run-off on roadway and shoulder.	80-100	Routine Maintenance.
Roadway surface well shaped with shoulder between roundings.Some distress manifestations in slight to moderate class such as loose gravel, dust, potholes, etc. There may be a few soft spots of frost heaving when evaluation is made in late spring. Good drainage for surface run-off on roadway and shoulder.	60-79	Routine maintenance. Dust control may be necessary for residential areas.
Mixture of properly shaped roadway surface and improperly shaped areas. Shoulder distress manifestations such as ponding and overgrowth evident between roundings in slight to moderate class. Various surface distress manifestations present such as washboarding, potholes, etc., in slight to moderate class. Localized breakup may be present.	40-59	Increased routine maintenance necessary. Addition of gravel and dust control additives become necessary.
Majority of roadway surface improperly shaped. Shoulder distress manifestations in moderate to severe class. Various roadway surface distress manifestations making travel unpleasant because of washboarding, dust, potholes, distortions, etc. Localized breakup areas.	20-39	Maintenance with addition of gravel necessary. Dust control a must for residential areas. Some portion may need rehabilitation.
Flat or reverse crown, severe roadway surface distresses such as washboarding, loose gravel, potholes, etc. Very rough on vehicles from severe distortion and breakup areas. Severe shoulder distresses trapping surface water at all times. Little or no gravel due to severe wind-row of loose gravel, on roadway surface.	0-19	Rehabilitation necessary.

(as reproduced from Chong and Wrong 1989)

Figure B-1 Pavement Condition Report

Ministry of Transportation

Regional Geotechnical Section

Pavement Condition Report

Condition Rating

District No._____Hwy. No.____W.P. No._____Length_____ _____

Location:_____

Reference No. From _____ To_____ Last Contract No._____

Offset Distance _____ _____ R.C.R. _____

Pavement: Type _____ Width_____ Shoulder: Width _____

Traffic: Year _____ A.A.D.T. _____ S.A.D.T._____% Trucks_____

Soils Data:

Pavement Structure Data:

Maintenance History:

Performance and Condition:

Remarks:

Proposed Remedial Measures:

Program Year: Present_____ Suggested _____

Date of Survey: _____ Prepared by: _____

(as reproduced from Chong and Wrong 1989)

An extensive guide is provided for completion of the form. Each parameter is checked (ticked) in the appropriate box and, in the absence of any detailed instruction for deriving the PCR, it *"is a subjectively derived rating number (0-100) describing the level of serviceability based upon the evaluation of the surface distresses. It is an assessment of the overall performance related to actual observable surface characteristics".*

The "Pavement Condition Report" form is used to record appropriate data (Figure B-1 from Chong and Wrong, and reproduced on p.24 of this report).

Discussion

This rating methodology does not include:

- Rating of side drains or water tables
- Roughness or riding quality assessment

The system does provide a single condition rating methodology for measuring the distress manifestations commonly found on unsealed roads in New Zealand and offers suggested maintenance treatments based on severity and density of distress. The system does not appear to be computer-based and this will require further detailed review to determine the feasibility of computer conversion. A road section methodology is used that is similar to the RAMM database.

Conclusion

This was (in 1989) proposed as a complete unsealed road rating system that could be considered further with respect to:

- Its conversion to a computer-based system,
- Its in-use performance for unsealed roads under New Zealand conditions.

Eaton, R.A. 1988. Development of the unsurfaced roads rating methodology. *Special Report No. 88-5.* US Army Corps of Engineers, Cold Regions Research and Engineering Laboratory (CRREL), Hanover, New Hampshire, USA.

Reference C3

This is an introduction to and a validation of the methodology for the field manual, Special Report 87-15 (see Eaton et al. 1987a, Reference C5).

Eaton, R.A., Gerard, S. 1991. Results of unsurfaced road rating surveys. *Transportation Research Record 1291:* 113-119. TRB, Washington DC, USA.

Reference C4

This paper records the results of the use of Special Report 87-15 in several US sites, and uses those results as validation for the original report (see Eaton et al. 1987a, Reference C5).

Eaton, R.A., Gerard, S., Cate, D.W. 1987a. Rating unsurfaced roads - a field manual for measuring maintenance problems. *Special Report 87-15 1987-08* (revised 1988-09). 34pp. US Army Corps of Engineers, Cold Regions Research and Engineering Laboratory (CRREL), Washington DC, USA.

Reference C5

Description

This is a complete manual on inspection and rating of unsealed roads. It notes that 2/3 of US highways and 90% of roads world-wide are unsurfaced low-volume roads. The method described is designed to work with the computerised PAVER or MicroPAVER pavement management systems developed by US Army Corps of Engineers but can also be used without a computer.

The scheme is based upon long term planning for 1-2 years compared to a 5-20 year term for surfaced roads, and upon planning or scheduling maintenance once a year.

Methodology

The three steps in rating condition of unsurfaced roads are:

1. Dividing the network into sections.
2. Inspecting the sections and identifying problems.
3. Calculating the ratings that indicate the condition for each section.

A sample rating inspection sheet is included (and is reproduced on p. 29 of this report). The objective is to record data on such a sheet and from the data derive an Unsurfaced Road Condition Index (URCI) and rating.

Step 1 Dividing the network

(a) Branches - major subdivision into roads by name.

(b) Sections - subdivision of branches into lengths of uniform characteristics. Within each section there should be consistency of:

- Structure, e.g. thickness and type of pavement materials
- Traffic, e.g. separate forest traffic from holiday traffic
- Construction history, e.g. divide by date of construction
- Classification
- Drainage and shoulders

(c) Sample Units - the smallest subdivision upon which observations are made. These should have:

- A length of 30 m but longer if width < 4 m and shorter if width > 10 m.
- An area of about 230 m^2 but can range from 150 to 350 m^2.
- Conditions representative of the section, e.g. if section has drainage problems include some problem areas in sample length.
- A frequency of about one unit per kilometre.
- Permanent marks on site for permanent identification.

Show all sections and sample units on a map.

UNSURFACED ROAD INSPECTION SHEET

Branch _____ Date _____

Section _____ Inspector _____

Sample Unit _____ Area of Sample _____

DISTRESS TYPES

1. Improper Cross Section (linear feet)
2. Inadequate Roadside Drainage (linear feet)
3. Corrugations (square feet)
4. Dust
5. Potholes (number)
6. Ruts (square feet)
7. Loose Aggregate (linear feet)

SKETCH

DISTRESS QUANTITY AND SEVERITY

Type		1	2	3	4	5	6	7
Quantity and Severity	L							
	M							
	H							

URCI CALCULATION

Distress Type	Density	Severity	Deduct Value

Total Deduct Value =

q =

URCI = RATING =

REMARKS:

☆ U. S. GOVERNMENT PRINTING OFFICE: 1988--500-057--82038

A sample of the inspection sheet that is supplied in the US Army Corps of Engineers field manual for rating unsurfaced roads (reproduced from Eaton et al. 1987a).

Step 2 Inspecting sections and identifying problems

(a) Windshield (drive over) inspection - full length of branch at 40 km/h. Note surface and drainage problems - to be done four times a year.

(b) Detailed measurement - of sample units annually, when roads are at their best and most consistent (this could be in the spring before they dry out, or in the autumn), and at same time each year.

Seven distress types are measured (a distress is an undesirable road condition):

1. Improper cross section (metres)
2. Inadequate roadside drainage (metres)
3. Corrugations (square metres)
4. Dust
5. Potholes (number)
6. Ruts (square metres)
7. Loose aggregate (metres)

Each distress type is divided into high, medium and low severity and is recorded on the rating sheet. The report gives illustrations of each severity, of each distress, and how to take measurements.

The distresses are measured in the units shown, but dust is measured merely by high, medium or low severity.

Step 3 Calculating the ratings

The distress measurements are used to calculate the URCI based upon "deduct values". A deduct value is a number from 1 to 100 where 0 means the distress has no impact and 100 means the road has failed.

(a) Calculate density for each distress type and severity level:

$$\text{Density} = \frac{\text{Quantity of Distress}}{\text{Area of Sample Unit}} \times 100\%$$

(b) Deduct value curves are provided. Read off deduct value from curves for each distress and severity level. No curve is provided for dust but deduct values are 2 for low, 5 for medium and 15 for high severity.

(c) Sum the deduct values to get Total Deduct Value (TDV) and derive q (on graph) from the number of deduct values greater than 5.

(d) From the URCI Curve read off the URCI and thus the rating from the scale.

This procedure gives URCI for each sample unit. For each section, mean the sample unit URCI; for each branch, mean the section URCI; and for the total network mean the branch URCI.

Thus sections and branches can be prioritised for maintenance expenditure, and network annual means can detect overall deterioration or improvement.

Units need to be converted to metric from the original imperial units in the text.
(The copy of C5 in *Supplement to Transit New Zealand Research Project No. PR3-0088* contains graphs of curves.)

Discussion
This rating methodology does not include:

- Roughness or riding quality assessment.
- Post-rating treatment recommendations.

The system is a complete unsurfaced pavement rating methodology that includes side drainage. It uses road sections selected under criteria similar to those used in the RAMM system, and can be used with or without computers.

Conclusion
This system measures and rates distress modes, including drainage, common to unsealed roads in New Zealand. Its road section criteria are closely aligned to those used in the RAMM system and it can be used on a computer. This system warrants further detailed review.

Eaton, R.A., Gerard S., Cate, D.W. 1988. Rating unsurfaced roads - adapted from US Army Corps of Engineers Special Report 87-15. ***Public Works March 1988 119 (3):*** **66-69.**

Reference C6

This paper is a brief description of the system proposed in Special Report 87-15 (Eaton et al. 1987a, Reference C5).

Eaton, R.A., Gerard, S., Dattillo R.S. 1987b. A rating system for unsurfaced roads to be used in maintenance management. ***North American Conference on Managing Pavements Proceedings 2:*** **2.52-2.62. Ministry of Transportation and Communications, Ontario, Canada.**

Reference C7

This paper is no more than a brief explanation of the system used in Special Report 87-15 (Eaton et al. 1987a, Reference C5).

Eaton, R.A. Gerard, S., Dattillo, R.S. 1989a. A method for rating unsurfaced roads. *International Road Federation 11th World Meeting, 1989*, Seoul, 4: 103-106. Korea Highway Corporation.

Reference C8

This paper reports in brief the proposals of Special Report 87-15 (Eaton et al. 1987a, Reference C5), and is a useful document to promote the use of that manual.

Eaton, R.A., Gerard, S., Dattillo, R.S. 1989b. Method for rating unsurfaced roads. ***The Northern Engineer 21(1&2):*** **30-40.**

Reference C9

This publication is a repeat of Reference C8 (Eaton et al. 1989a) but in another journal.

Gerke, R.J., Tooma, G.G. 1990. Road pavement management - information needs of a roading authority. ***Road Engineering Association of Asia and Australasia 6th Conference, 1990, Kuala Lumpur.*** **Road Engineering Association of Asia and Australasia, Kuala Lumpur, Malaysia.**

Reference C10

Description

This paper reports the road pavement upkeep information needs of all management levels in the Roads and Traffic Authority (RTA) of New South Wales, Australia. The types and responsibility for collection of data for a complete Pavement Management System (PMS) are discussed.

The information required by RTA is grouped into five main areas:

- network road inventory
- network road condition
- network standards
- road and network deterioration models
- network costs

The PMS used by RTA uses three major computer programmes:

- CMIS - Condition Management Information System
- TNOS - Treatment Scheduling Network Optimisation System
- FNOS - Financial Planning, Network Optimisation System

The network inventory and condition is entered to these three systems by CRIS (Continuous Road Inventory System), and located within the network by ROADLOC (Road Data Location System).

As this is a total PMS it includes all road types, and provision is made in ROCOND 87 (Road Condition) for rating unsealed roads for shape and surface condition, but without any details of the rating methods or measurements being given.

Conclusion

This is not a stand-alone unsurfaced road condition rating system. However further review is warranted in terms of the methodology and end use. Complete system details could probably be obtained from Australia.

Hopwood II, T., Sharpe, G.W., Hutchinson, J.W., Deen, R.C. 1987. Automated data requisition for low-volume road inventory and management. *Transportation Research Record 1106:* 67-73. TRB, Washington DC, USA.

Reference C11

Not relevant, but publication has been retained for interest in *Appendix C to Transit New Zealand Research Project No. PR3-0088,* held at Transit New Zealand.

Isotalo, J. 1987. Question VI - Roads in developing regions. Report from Finland. *PIARC XVIII World Roads Congress, Brussels, Belgium:* 275-292. PIARC Paris, France.

Reference C12

Description

This paper outlines a complete maintenance management system and includes a simple rating scale for riding surface condition of gravel roads.

The condition of the riding surface is the decisive factor in determining the condition of gravel roads as this is the serviceability factor which can be changed by maintenance activities.

Methodology

The riding surface condition may vary from 1 (bad) to 5 (excellent) in accordance with the Rating Scale in the table below and the quality criteria used. Roughness values have been determined with a bump integrator in the laboratory and are in centimetres/kilometre.

Rating Scale For Gravel Road Wearing Course Condition	
Rating	**Condition**
<1.0	Shape of road cross-section has changed in several spots; surface is uneven due to potholes, corrugation and ravelling; settlements and humps on the road that cannot be avoided; plenty of dust; road surface must constantly be watched and running speed often changed; roughness more than 400 cm/km.
1.1 - 2.0	Shape of road cross-section may have changed somewhat; some corrugation on the surface; local settlements or humps marked with traffic signs; moderate dust; lower running speeds sometimes needed and uneven spots must be avoided; roughness 361-400 cm/km.
2.1 - 3.0	Road surface has generally maintained its shape and is mostly even and firm; minor potholes and unevenness; some dust; potholes and uneven spots can be avoided, or they are such that the running speed can be maintained; in giving way to overtaking or oncoming vehicles a lower running speed should be used; roughness 321 - 360 cm/km.
3.1 - 4.0	Road surface has generally maintained its shape and is even and firm; some single potholes here and there; no dust; running speed can be maintained in spite of unevenness; roughness 281 - 320 cm/km.
4.1 - 5.0	Road surface has maintained its shape and is very even and firm; possible unevenness of surface does not affect driving comfort; roughness less than 280 cm/km.

(Rating Scale copied from Isotalo 1987)

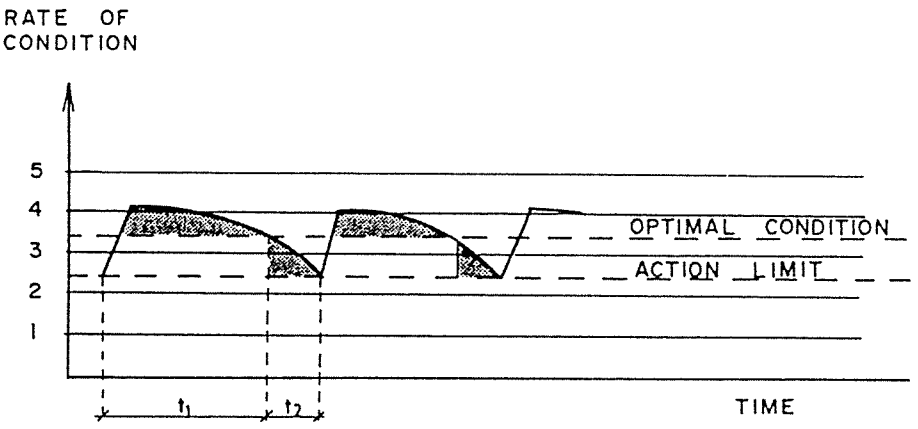
The quality criteria which determine the rating of condition are:

Evenness of the surface	- potholes - cracks - ruts - corrugations
Firmness of the surface	- amount of loose gravel
Dust	
Form of cross-section	- camber - high shoulders

The rate of condition number is evaluated by comparing a set of colour prints with the existing road surface, together with a verbal definition of the quality criteria.

In the discussion of the principles of changes in gravel road surface condition, Isotalo noted that deterioration is not linear but accelerates (as shown in Isotalo's Figure 6 reproduced below).

Figure 6. The principles of changes in gravel road surface condition.



(Reproduced from Isotalo 1987)

For maintenance class I during summer, roads should be at the *optimal condition* level (about scale 3.4, as on Figure 6 above). This is taken as an average of each kilometre of road. The *action limit* (about scale 2.5, as on Figure 6 above) is the worst condition that can be accepted for a whole road section and at which point appropriate maintenance action must be taken.

Maintenance classes I and II differentiate between roads with ADTs of over or under 200 vehicles per day (vpd) respectively. The scales for class II are 2.8 and 2.0 when compared with the levels for class I. Action times are 1 to 4 days for class I and 1 to 6 days for class II.

The maintenance task is to keep the condition of the road above the action limit and to reach the average optimum condition.

Short range management (over 1 to 4 weeks) and appropriate observations are necessary to achieve the benefits of this two level system. Long range planning ensures that actions are as infrequent as possible ($t_1 + t_2$ from Isotalo's Figure 6).

Observations should be:

- made 2-3 times per month for class I
- made 1-2 times per month for class II
- taken at one per kilometre
- recorded on an appropriate form
- recorded by comparing observations with a set of typical photos
- entered and analysed by computer

Comparisons can be made between roads and districts, and the work can consequently be prioritised.

It is noted that *"gravel roads, contrary to paved roads, need 'constant' caretaking and various maintenance measures"*.

Discussion

While this system uses colour print photography as standards for comparisons and written descriptions of road condition, the evaluation of road quality criteria is largely a combination of visual assessment and road roughness measurements. It has no provision for either rating side drainage or any specific recommended treatment link, apart from optimal condition levels below which action is required.

Conclusion

This simple rating system uses visual quality criteria to assess elements of gravel road performance that are also common to unsealed roads in New Zealand. No details are given of dividing the road network into sections. The system is suitable for microcomputers and forms part of a complete gravel road PMS methodology to record deterioration rates and maintenance intervention levels. The system will warrant further review with respect to methodology but, as it is based on visual assessments, relies on the inspector for consistency.

Kennedy, C.K., Butler, I.C. 1990. Road assessment survey systems. ***Highways and Transportation 37 (2):*** **Feb 1990.**

Reference C13

The essential content of this article is concerned with using mobile high speed vehicles designed to collect survey data on roads. While most of the equipment is more suited to paved roads because of the wide range of data collected, the equipment seems to be applicable also to unsurfaced roads. The paper has been retained, for interest, as *Appendix C to Transit New Zealand Research Project No. PR3-0088* held at Transit New Zealand.

Männistö, V., Tapio, R. 1990. Maintenance management on gravel roads. *Transportation Research Record 1268:* 170-172. TRB, Washington DC, USA.

Reference C14

Description

This paper refers to a system used by Finland Roads Administration (RWA) for the 42% (32,000 km) of its network of unsurfaced roads. The paper is incomplete because it refers to "semi-Markov" models without defining the procedure or outcomes of using these models.

The three variables used to describe the condition of a gravel road are defined as follows:

- *State Variables* - factors (elements) which are assumed to remain constant during summer; maintenance actions directed at these factors usually last more than one year.

- *Condition Variables* - describe the condition of the gravel road during the summer maintenance season; effect of summer maintenance lasts only for that season.

- *Control Variables* - describe all other variables that will not change over time (except Average Daily Traffic (ADT)).

Particulars of these variables are:

- *State* - thickness (cm) and quality of wearing course, and road structures (index).

- *Condition* - amount of loose aggregate (index 1-5), longitudinal roughness (subjective index 1-5), and longitudinal roughness (bump integrator in cm/km).

- *Control* - ADT (summer vehicles per day (vpd)), geographical region (south or north), and road geometry (good or poor).

The paper records a sampling of 360 km of gravel roads, using sample lengths of 2.5-3 km with measurement data recorded every 500 m. State variable measurements are measured at every sample kilometre twice a year. Factors describing the road structure condition are assigned every spring when road conditions are worst. Condition variable measurements are monitored weekly. Other measurements are provided by the RWA databank.

All variables are used as classified variables where 1 is good, 2 is fair, and 3 is poor.

State and condition variables are:

Variable	Good	Fair	Poor
Thickness of wearing course (cm)	≥ 5	—	< 5
Road structure (index 1–5)	4–5	3	1–2
Roughness (cm/km)	< 200	200–300	>360
Loose aggregate (1–5)	4–5	3	1–2

Control variables are:

Variables	Classification
ADT (vpd)	< 100, 100–200, > 200
Road geometry	Good, Poor
Geographical region	North, South

The computer analysis is aimed at obtaining maintenance management by predicting deterioration of state and condition variables when maintenance works have or have not been carried out on the sample units.

This system seems to be used to assess deterioration of an entire system by examining an approximate 10% sample.

Discussion

The system is suitable for use with computers. It relies on roughness measurement and thickness of wearing course as the keys for objectively measuring condition variables. Loose aggregate is estimated by visual inspection following RWA instructions. The road condition rating system is linked to road deterioration and maintenance effect modelling.

Summary

As distinct from the other Finnish system discussed under Reference C12, this methodology relies on road roughness and not on physical measurement of key elements of gravel road distress such as cross-section shape, potholes and drainage, as is done in New Zealand. The system is unlikely to warrant further review for a road condition rating methodology.

Mercier, C.R., Stoner, J.W. 1989. Road sufficiency rating system model validation. *Transportation Quarterly 43 (3):* 361-372. Eno Foundation for Transportation Inc., Westport, Connecticut, USA.

Reference C15

The paper is not relevant, but has been retained, in *Appendix C to Transit New Zealand Research Project No. PR3-0088* held at Transit New Zealand, for interest and background.

Mulholland, P.J. 1991. Pavement management systems for local government - the guidelines report. *ARRB Research Report No. 188.* Australian Road Research Board, Victoria, Australia.

Reference C16

Description

This report, covering a much wider field than Transit New Zealand Research Project No. PR3-0088, includes some information on road condition surveys and some references to candidate ranking which are relevant. The PMS output is also of interest even though it is not confined to unsealed pavements.

The following are some extracts from the executive summary:

"The several levels of management in local government can benefit from the development of:

- *a road inventory*
  - *up-to-date knowledge on the basic asset, the road network;*
- *a road condition data bank*
  - *recording how the road network is changing in condition;*
- *a treatment selection process*
  - *determining the optimum or best treatment for a particular section of road for given circumstances;*
- *priority formulation*
  - *a means of ranking treatments;*
- *budget preparation methods*
  - *applying estimated costs to the ranked treatments and sorting projects by year according to given funding constraints."*

And further:

"Condition surveys should be performed at sufficient intervals to monitor pavement condition changes that will affect selection of rehabilitation or maintenance alternatives. Road sections in relatively poor condition may need to be surveyed annually, while new sections with relatively good performance may be evaluated every two or three years. In larger road networks, it may be necessary to give priority to major roads and collectors, and survey these roads annually.

"Different levels of survey can be carried out:

***Survey, Level 1,** is a subjective observation of the extent and severity of each distress type, which gives an overall rating score. This form of condition data is most likely to be restricted to showing changes in condition at the network level.*

*"**Survey, Level 2,** involves noting each different defect by recording a measure of extent and a measure of severity. The resulting condition data should be precise enough to enable the existing condition and the changes in condition to be defined at both project and network levels.*

"The Guidelines Report provides guidelines on how to undertake such surveys. It also indicates the nature of cost data that should supplement the road condition data."

Methodology

The Guidelines Report indicates the types of distress to be surveyed for unsealed roads as:

Survey Level 1	Survey Level 2
Deformation	{Rutting {Corrugations {Channelling {Shoving
Disintegration	{Potholes {Loose material {Dust

The following points are relevant when deciding which survey level is appropriate:

Survey Level 1: Resulting condition data are capable of adequately defining the existing condition of a pavement. Because these data may not indicate changes of condition at a project level, they should be restricted to showing such changes at the network level.

Survey Level 2: Resulting condition data should be precise enough to enable the health of networks to be assembled at any level in conformity with "the interim condition indices" as recommended by AUSTROADS (1987):

Roughness Index:	Counts/km (NAASRA meter)
Rutting Index:	Percentage of pavement with either isolated, intermittent or widespread rutting >20 mm deep.
Cracking Index:	Percentage of pavement with either isolated, intermittent or widespread cracking >2 mm wide.
Surface Texture Index:	Percentage of pavement with any degree of texture loss.

Reference is made to two earlier publications:

- AUSTROADS 1987. A guide to the visual assessment of pavement condition. NAASRA (now AUSTROADS), Sydney.

- Mulholland P.J. 1989. Pavement management systems (PMS) for local government: State-of-the-art report. *Research Report ARR No. 174.* Australian Road Research Board, Victoria, Australia.

The report suggests that 10% of the network be surveyed by close visual inspection and that data is collected on a specially designed form, a laptop computer or a data logger.

The report develops a theory of candidate ranking to identify sections which have the worst condition overall and are deteriorating the quickest. Factors to take into account when ranking projects are:

- Pavement condition,
- Rideability (roughness),
- Age of pavement, and
- Road importance (traffic).

Discussion

This guidelines report is designed to assist roading authorities implement PMS and evaluate alternative systems. It is not a detailed road condition rating system that is in present use. However it does identify that the key "condition variables" for unsealed roads are rutting, corrugations, channelling, shoving, potholes, loose material and dust.

These "condition variables" are consistent with the factors that also affect the performance of unsealed roads in New Zealand.

Conclusion

This paper provides guidelines for the selection of PMS including unsealed road condition rating systems and its candidate ranking procedures are worthy of further study when considering the way in which condition rating data may be utilised.

OECD. 1990. ***Road monitoring for maintenance management. Vol. 1 Manual for developing countries.*** **113pp.** ***Vol. 2 Damage catalogue for developing countries.*** **91pp. International Bank for Reconstruction & Development, Washington DC, USA.**

Reference C17

Description

While this system is intended for use in developing countries it could form the basis for a useful rating system for unsurfaced roads in New Zealand. Because of its application to developing countries, it goes to great lengths to detail staff and methods required for the damage surveys. Forms used are included in the review.

It is assumed that a location reference system and a road inventory are in place. Basic requirements for a well organised system are:

- Division of the network into sections and subsections that are as homogeneous as possible.
- Every section and subsection should be identified by a simple code comprising road, section and subsection number.
- A standardised system of data collection.

It is suggested that a functional classification based upon AADT (annual average daily traffic) and category should be incorporated into the network subdivision, and that a simplified road map should be prepared to show the subdivisions. Examples are given of how sections and subsections should be referenced in the field.

Methodology

The monitoring scheme is based on two levels of inspection:

- Road Condition Survey (RCS)
- Detailed Visual Inspection (DVI)

RCS is conducted over the entire network at least annually, and DVI on at least those sections identified by RCS as needing major maintenance. If there are no constraints both could be used over the entire network, or a set of representative sections could be set up and sampled for long term evaluation data. Monitoring at rates of 30-50 km/day could be achieved for RCS and 5-8 km/day for DVI.

A set of forms is used to record the data collected.

(Form I) This is a form for recording inspection itineraries for either RCS or DVI.

RCS (Forms II and III)

Four groups of parameters are identified on these forms:

- Carriageway (one parameter on a 5-point scale).
- Roadside components or elements as well as obstructions (six parameters on a 3-point scale).

- Road signs and furniture on a 3-point scale.
- Road structures (3 parameters on a 3-point scale) - recorded on Form III.

RCS (Forms IV and V)
Results are meaned for each subsection, entered on Forms IV and V (for structures) and decisions are made as to the next steps. If the results are satisfactory no action is taken. If the carriageway condition is unsatisfactory, then a DVI is undertaken of the offending section. If the need is shown to be for components or structures, appropriate maintenance is undertaken.

DVI (Forms VI - VIII)
DVI is carried out only when RCS indicates an unsatisfactory road condition. Parameters (elements) inspected on carriageway only are:

Rutting	Erosion gullies
Corrugations	Potholes
Camber/crossfall	Clay
Gravel thickness	

These are recorded on Form VI for unpaved roads. (Similar elements are recorded on Form VII for paved roads.)

These parameters are assessed relative to their influence on vehicle operating costs, traffic speed and driving safety. The assessment requires very detailed measurement. Each parameter is assessed on a 5-point scale rated by:

- % extent of damage
- Severity of damage

DVI results are meaned for each subsection and combined into an arithmetic length weighted average for the whole section. Averages are carried forward to Form VIII.

A typical chart for assessing the 5-point scale where severity is read against extent is given below (and in Section 5 of this report):

Rating Criteria (from Volume 2 - refers to corrugations)

Evaluation					**Class** Severity		
	Extent	Severity			1	2	3
1	< 10%	< 20 mm		1	1	3	4
2	10-50%	20-50 mm	Extent	2	2	3	5
3	> 50%	> 50 mm		3	3	4	5

Interpretation of results will conclude that either:

- maintenance or rehabilitation is required short term, or
- maintenance or rehabilitation is required medium term.

Data storage and recovery by computer is recommended although only the desirable outcomes are listed with a few examples, and, while the processes involved in reaching these outcomes are outlined, no programmes are mentioned or recommended.

Discussion

The unsealed road condition rating system of this manual contains detailed objective measurement of seven distress areas that form the basis of this system. These are supported by training notes. While most of the distress areas are common to New Zealand conditions, Erosion Gullies (washouts) and Clay could be substituted with more common New Zealand problems such as loose gravel and dust.

Conclusion

This system warrants further evaluation under New Zealand conditions. The methodology and detail could easily be adapted to define criteria that are appropriate for New Zealand conditions. The road network requirements are similar in structure to the RAMM database, i.e. road sections and dimensions.

Riverson, J.D.N., Sinha, K.C., Scholer, C.F., Anderson, V.L. 1987. Evaluation of subjective rating of unpaved county roads in Indiana. *Transportation and Research Record 1128:* 53-61. TRB, Washington DC, USA.

Reference C18

Description

This research paper primarily evaluates the relationship between user ride comfort (PCR - a dependent variable) and road roughness. Five US counties were selected for the study. Panels of users were asked to rate unsealed roads in terms of the following distress types:

- Rideability (ride comfort)
- Corrugations
- Rutting
- Potholes
- Gravel looseness
- Side drainage
- Camber/crossfall

Each distress type was rated on a scale 1 (very good) to 5 (very poor). These rating scales had specified criteria that in most cases could be measured on the road.

Discussion

While not a specially designed unsealed road condition methodology, this study did develop useful distress and rating specifications.

Summary

The study may be of use in determining distress rating scales and specifications for unsealed roads in New Zealand.

Sullivan, T., Scott, R. 1990. Strategic road network management - an approach using roughness. ***Road Engineering Association of Asia and Australasia 16th Conference, 1990, Kuala Lumpur.*** **Road Engineering Association of Asia and Australasia, Kuala Lumpur, Malaysia.**

Reference C19

Description

The system outlined in this paper is based on a method for the prediction of remaining pavement life using road roughness data. While not confined to any particular pavement type it seems applicable to unsealed roads. The one aspect that handicaps such a system for use on unsealed roads is the rapidity of increase, and even reversal, of roughness on such roads. The abstract says *"The Roughness Methodology, with Cost Model, has the potential to provide an uncomplicated, flexible, technically appropriate approach to Strategic Road Network Management".*

The underlying hypothesis of the method is based upon extrapolating to an agreed roughness threshold from historical increases in roughness over time, so that it should be possible to provide a broad prediction of remaining pavement life before major rehabilitation is needed, and is signalled by the threshold. The threshold has been taken as 140 counts/km, which is the AUSTROADS (formerly NAASRA) indication of poor quality of service from a road.

Investigations on Roughness/Pavement Age have been extensively undertaken throughout Australia. However the predicted lives seem mainly to be in excess of 20 years, and this seems very optimistic. The system has many advantages, not the least being its low cost.

Discussion

The question with this system is whether roughness measurement on its own is a satisfactory basis to determine levels of service and maintenance intervention levels on unsealed roads.

Conclusion

The role of roughness in any unsealed pavement condition rating system will require careful evaluation against other methods of road distress measurement, such as rutting and corrugations. This paper may provide useful background in evaluating the role of roughness in such a system.

Transportation Information Center. 1989. *Gravel-PASER Manual.* College of Engineering, University of Wisconsin, Madison, USA.

Reference C20

This publication had not been received by 31 January 1995, and apparently is unavailable in USA. Walker (1991) presented information about the manual in his paper, evaluated in this report as Reference C23. It appears to be an important manual.

Visser, A.T. 1981. ***An evaluation of unpaved road performance and maintenance.*** **PhD Thesis, University of Texas, Austin, Texas, USA.**

Reference C21

This thesis sets up a Maintenance and Design System (MDS) for unpaved roads. It does not include a rating system and has therefore not been reviewed further.

Visser, A.T. 1985. Review of the use of maintenance and design systems for managing unpaved road networks. *Paper 2B/14.* TRRL, London, UK.

Reference C22

The publication had not been received by 31 January 1995, and apparently is unavailable in South Africa or the UK. It does not appear to be relevant.

Walker, D.M. 1991. Evaluation and rating of gravel roads. International Conference on Low Volume Roads, Raleigh, North Carolina. *Transportation Research Record 1291:* 120-125. TRB, Washington DC, USA.

Reference C23

Description

This paper is about the "Gravel-PASER" system developed by the Transportation Information Center of University of Wisconsin, in Madison, USA.

Key steps in developing a roadway management system are:

- Break roadway system into individual segments of similar pavement thickness and traffic volume.
- Include inventory information on the segment such as geometrics, traffic volume, functional classification.
- Provide some assessment of roadway condition.

By providing details of type of distress, its extent and severity, an overall indicator of condition is developed. Prioritising maintenance and rehabilitation projects can be achieved by automated computer processing or manually.

PASER uses a visual rating. Only data that will be used should be collected. The overall rating scale is directly related to the type of maintenance or rehabilitation most appropriate to the segment.

Methodology

Rating is based upon the three major factors that affect performance:

- Roadway crown
- Drainage
- Gravel layer

Other distresses such as rutting and potholes are indicators of inadequate load-carrying ability and are a good indication of gravel depth adequacy. Of secondary interest are washboarding, loose rock and dust which are primarily indications of traffic distress and of the adequacy of recent maintenance activities.

A simplified 5-point scale, from 5 (excellent) to 1 (failed), has been developed. Each category is intended to indicate conditions directly related to the need for maintenance or rehabilitation. This scale, detailed in Table 1 of Walker's paper, is shown in full on pp.90-91 of this report.

Segment lengths average 1.6 km in Wisconsin and rating surveys should cover 30-60 km/day. Surveys should be done annually, in autumn or spring.

While not specifically discussed (and perhaps the PASER manual does this), presumably the ratings are totalled to devise ratings for each individual segment. The higher the number, the better is the condition.

Discussion

The PASER system warrants further review.

Transit New Zealand. 1994. *RAMM standards and guidelines. Part II: Unsealed road condition rating standards.* Issue 1, 30pp. Prepared by Beca Carter Hollings and Ferner Ltd for Transit New Zealand, Wellington, New Zealand.

Reference C24

Description

This manual was issued during the period (1993-1994) between the two literature searches that were carried out for this research project. Its issue virtually pre-empts this project.

The RAMM manual is a complete document covering all aspects of rating survey procedures in simple language and is clearly the best that was reviewed for this project. It is the only system with a New Zealand flavour, which immediately recommends it. Probably the principal difference from the overseas contributions is the lack of an index to rate road sections. This system (as does that of Hallett and Jacobson 1994, Reference C25) separates each maintenance defect aspect. Thus, when reports are extracted from the database, lengths of road that require attention for each aspect are output, rather than an analysis of total lengths of each index number indicating an annual maintenance assessment. While the Transit New Zealand method may well be the more appropriate for state highways, City and District Councils might prefer the index approach used in overseas systems.

Methodology

A prime requirement of any rating survey is the completion of a base inventory and its entry to form the basis of the database. The purpose of rating surveys is usually to observe, measure and record defects in each element in a standard and objective manner. The selected inspection lengths are walked over and defects entered on a standard form or into a data logger.

The road network is divided into Road Sections which are the base unit of the system, and divisions would normally occur at intersections or other predominant features. Each road section is divided into Rating Sections, nominally 500 m long but located within specified limits of accuracy. For each rating section, a 50 m Inspection Length is located within which data are recorded. A typical arrangement given in the manual shows the relationship between these three levels of subdivision.

Mention is made of a computer programme (elsewhere referred to as *AUTO-RATE*) which pre-prints survey forms showing descriptions, locations and displacements of sections and lengths, and upon which observations are recorded (Table 1 in the RAMM manual is reproduced in this report on p.58). A list of recommended equipment is included, as well as a typical cross section of an unsealed road.

AREA: WELLINGTON 09mar94 Form 131

UNSEALED ROAD CONDITION RATING FORM

ROAD: Sub-area: 23

Road No. [640 Name ROBERTSON RD

SECTION:

Start Displ. [0] Name DAVE RD

End Displ. [1697 Name MCKAY RD

RATING SECTION:

Rating Start Displ. [500] Inspection Start Displ. [500]

Rating End Displ. [1000] Inspection End Displ. [1000]

Rating Date: 23/3/94 **Surveyed By:** CDMC

CARRIAGEWAY: - **Number of Traffic Lanes** (2)

	Pot Holes (No.)											
Diameter	100 - 300mm dia			300 - 600mm dia			600 - 900mm dia			> 900mm dia		
Depth	25-50mm	50-100mm	100mm+	25-50mm	50-100mm	100mm+	25-50mm	50-100mm	100mm+	25-50mm	50-100mm	100mm+
	2 1 1			1 1	1			3		2 2		
Totals	4	✓	✓	2	1	✓	✓	3	✓	4	✓	✓

		Improper X-Section (m)	Scour (m2)	Shove (m)	Rut >40mm (m)	Corrugations (m2) 25-75mm	Corrugations (m2) >75mm	Loose Aggregate (m) 50-100mm	Loose Aggregate (m) >100mm	Loose Aggregate (m) Top size (mm)	
LHS	12	1	5		25	6		50	50	20mm	
LHS	38	0	(12)		7					40mm	✓
RHS	12	1								60mm	
RHS	38	1									
Totals		3	17	✓	32	6	✓	50	50		40

SURFACE WATER CHANNELS

LHS SWCs Block (m)	LHS SWCs Inad (m)
	130
	60
	45
Totals	235

RHS SWCs Block (m)	RHS SWCs Inad (m)
	250
	65
	10
	42
	367

	Loose Agg Depth Scratch Box		
	LHS	Cway	RHS
12	80	0	120
38	40	25	90
Ave Depth	60	12	105

Comments

Table 1 (reproduced from RAMM manual)

Road elements to be measured (Table 1, reproduced on p.58 of this report) are subdivided into Carriageway and Surface Water Channels. The following lists are the descriptions and methods of measurements to be made for each element.

CARRIAGEWAY

- *Potholes*

These are counted in each of twelve sizes, defined by their average diameters which are:

(a) 100-300 mm
(b) 300-600 mm
(c) 600-900 mm
(d) > 900 mm

and by their maximum depths of:

(e) 25-50 mm
(f) 50-100 mm
(g) > 100 mm for each diameter class.

Measurements are made with straightedge and rule.

- *Improper Cross Section*

This fault is evident when either half width of the inspection length, measured at the 1/4 (12 m) and 3/4 (38 m) points, has a crossfall of less than 5% or 100 mm in 2 m of width. Thus four measurements are made per inspection length. Each one showing less than 5% is counted as 1 and each "passing" counted as 0. A total in the range 0-4 is thus adduced for each inspection length.

Measurements are made with a 2 m straightedge fitted with a spirit bubble and a 100 mm vertical leg at one end.

- *Scour*

Surface scouring of the carriageway is measured in square metres of area, length by average width assuming a minimum width of scour of 0.5 m. For each inspection length, total area is recorded.

- *Shove*

This kind of shallow shear is evidenced by a hollow and accompanying lateral bulge. In each inspection length, the total length of wheelpath showing shoving is measured in metres.

- *Rut*

A surface depression without the accompanying lateral bulge of shoving. Measured in metres of total length of wheelpath rutted to a minimum depth of 40 mm in each inspection length.

- *Corrugations*

These ridges are normal to traffic direction and are measured in total area in square metres occupied by corrugations either between 25 and 75 mm deep, or over 75 mm deep. The area is determined by the length of the affected area times average width of corrugations for the two depths.

- *Loose Aggregate*

Loose aggregate is shown by the presence of windrows. It is measured at the 1/4 and 3/4 points along the inspection length as the depth of windrow at each carriageway edge and at the deepest windrow between. Each windrow is averaged for depth. When the average for any windrow exceeds 50 mm, the entire 50 m inspection length is recorded as either 50-100 mm deep or more than 100 mm deep, or both, as appropriate.

- *Top size*

The average topsize of the running course aggregate is obtained by measuring the least dimension of the predominant large stone size categorised as 20, 40 or 60 mm. The appropriate box on the form is ticked.

EARTH SURFACE WATER CHANNELS

(a) Blocked

This category is applied to surface water channels blocked by earth or vegetation so that they are ineffective. Measurements are of lengths, in metres on each side of the road, over a full rating section (500 m).

(b) Inadequate

Where the invert of a surface water channel is less than 300mm below the edge of carriageway, or water flow is prohibited by a high or flat shoulder (flatter than 1 in 10), the channel is inadequate. Measurement is in metres for each side of road, over a full rating section (500 m).

- *Comments*

The rating form provides for recording items requiring attention but not included in the above nine elements, e.g. slips, subsidence and dropouts.

Discussion

Unlike all other systems reviewed, the RAMM manual gives complete details of sampling and measurement procedures and little else. It is therefore probably the only system which is totally relevant to unsealed roads.

The elements measured are all appropriate but the omission of dust measurement is noteworthy. While quantifying dust is not simple, there is merit in the original US Army Corps of Engineering rating of dust as of high, medium and low severity, even though this introduces an element of subjectivity.

In many areas in New Zealand, particularly with horticultural activity, dust has a significant effect on properties fronting unsealed roads as well as on road users.

Aggregate loss is another aspect which could advantageously be measured and indexed.

Conclusion

Clearly considerable work has gone into this manual and the result is a credit to its authors. It is the most complete system reviewed and appears to meet most local requirements.

It is recommended that dust is included in the road elements assessed and that provision is made for a condition index to facilitate, or even enable comparison of, overall maintenance assessments between roads, areas or districts, and prioritisation of remedial activity.

The need for twelve classifications of potholes is questioned, and the inclusion of Aggregate Loss as an element to be assessed is suggested.

Hallett, J.E., Jacobson, P. 1994. Pavement management systems for unsealed roads. ***Proceedings NZ Land Transport Symposium 1994, 1:*** **137-144.**

Reference C25

Description

This paper reports work undertaken by Beca Carter Hollings and Ferner Ltd for Far North District Council (FNDC), North Island, New Zealand. It covers the development of a road rating procedure for unsealed roads emphasising maintenance reporting features and the storage of the data in the RAMM database.

The basis of the system is the US Army Corps of Engineers Special Report 87-15 (Eaton et al. 1987a, Reference C5) supplemented by data from the NAASRA roughness surveys. The US procedure was adapted for New Zealand conditions and the assessments were made more objective.

With respect to the road condition rating survey procedure this paper claims that *"The procedure developed has been adopted by Transit New Zealand and a manual for carrying out such surveys has been developed".*

It does not include the survey procedure details but, because of the common source (Beca, Carter, Hollings and Ferner Ltd), it is assumed that the procedures used in the RAMM manual (Transit New Zealand 1994, Reference C24) were also used by the FNDC. The features measured certainly coincide, apart from some minor terminology and classification differences.

Methodology

With the exception of surface water channels of which the full length is checked for drainage discrepancies, 50 m of every 500 m of the road carriageway is assessed for the following faults:

- Loose aggregate (includes aggregate topsize)
- Corrugations
- Crossfall (cross section shape)
- Potholes
- Rutting
- Shoving
- Water scour

Both the features measured and the properties of road assessed are similar to those given in the RAMM manual.

The surveys in the Far North District were undertaken in 1992-1993. Road roughness surveys have been undertaken over the years 1990-1993. Results of Road Roughness and Road Condition Rating Surveys have been stored in the RAMM database and reports have been developed to analyse the data and to report broad categories of road maintenance requirements.

The paper concentrates on the details of the reports, their form and purpose, rather than on the actual condition ratings. It has been assumed that by default the survey methodology is that described in the RAMM manual.

Reporting

While Hallett and Jacobson's paper concentrates on the ability of the system to furnish reports based on collected data, and the details of carrying this out, such matters were beyond the scope of this review.

For each category of maintenance defect that is listed, reports can define sections of carriageway requiring attention by the input of "trigger" values for the variables. The trigger values indicate the worst acceptable rating. The following are the trigger values selected by the FNDC.

1. Drainage

A candidate list of carriageway sections showing both drainage discrepancies and drainage-related pavement distress is provided, and either all drainage deficient sections or only those with drainage associated pavement deficiencies can be reported.

The factor reported and the selected trigger values to report rating sections with both deficient drainage and associated pavement faults are:

- Deficient drainage (% inadequate plus blocked) >= 25%
- Pavement deformation (length of rutting plus shoving) >= 3 m
- Water scour (area in m^2) >= 3 m^2

To report deficient drainage but no associated pavement faults the following trigger values are input:

- Deficient drainage >= 70%
- Pavement deformation >= 0 m
- Water scour >= 0 m^2

2. Loose Aggregate

A list is produced of sections with excessive loose aggregate which indicates excessive or unsuitable running course, including aggregate topsize. The trigger value input is 100 m length of windrow with an average depth of 50 mm or more.

3. Corrugations

Sections with corrugations severe enough to require cutting and relaying are listed. The unit measured is area of corrugation in m^2 where the depth exceeds 75 mm. The trigger is 10 m^2 per inspection length which equates to 4% of the carriageway area.

4. Improper Cross Section/Potholes/Rutting/Shoving

Sections with improper cross section, indicated by a crossfall of less than 5% and associated pavement distress, are listed either separately or together. Units measured are % of length showing improper cross section, number of potholes, and lengths (metres) of rutting and shoving.

Trigger levels are set as follows:

- Deficient crossfall >= 50%
- Potholes >= 5 each
- Rutting >= 5 m
- Shoving >= 5 m

Provision is made to exclude sections already reported under *1. Drainage.*

5. Pavement Structural Deficiencies (Rutting/Shoving)

Sections deficient in pavement strength can be reported where trigger levels are exceeded and the deficiencies are caused by neither drainage nor shape defects. The trigger levels are set at 5 m each for either rutting or shoving. Provision is made to exclude those sections reported under *1. Drainage,* or *4. Improper Cross Section.*

Estimate of Road Maintenance Requirements

Totalling the lengths of road represented by sections that are reported as requiring attention, gives a broad list of maintenance requirements under each of the report categories. The work required may then be assessed and costed.

Subsequent rating surveys when compared with those of earlier years may indicate the efficiency of maintenance treatments. Improved roughness readings may also indicate improved maintenance procedures where traffic volumes have remained the same.

The paper makes it clear that the trigger levels that have been set, to enable defect reports to be extracted, are as yet unproven. As the maintenance requirements are heavily reliant on the trigger levels selected, it would be prudent to calibrate these against current maintenance effort as a first attempt to prove the validity of the procedures and of the inputs used.

Cyclic maintenance is handled separately by the contractor responsible for grading and running course application. This work is required to meet a specified standard.

Report Conclusions and Recommendations
The paper discusses further development for using the results, including financial analyses for seal extension and unsealed smoothing. The value of reported data to management of maintenance contracts is detailed, together with benefits accruing to the local roading authorities.

Recommendations include the development of treatment selection programmes and prediction models, and also detailed recording of maintenance effort within the RAMM database.

Discussion
This paper deals more with the usefulness of condition rating data than with the data themselves. If the methodology either from Special Report 87/15 (Eaton et al. 1987a, Reference C5) or the RAMM manual (Reference C24) can be assumed, then this paper adds little to the present project, except for the manner of extracting reports from the database indicating sections requiring attention in each aspect or group of aspects.

Conclusion
Because of the common "parenthood" for the RAMM manual and this paper, comments in common have been applied to the RAMM manual (Reference C24), rather than to this paper which includes nothing with respect to condition rating surveys or methodology as such.

Department of Transport UK. 1992. National road maintenance condition survey. Report on 1991 Survey. *Statistics Bulletin (92) 30.* 66pp. Standing Committee on Highway Maintenance, Eastcote, Middlesex, UK.

Reference C26

Description

While this publication comprises survey results covering all roads in England and Wales with a view to comparing present with past conditions, there may be some relevance to unsealed road condition rating in New Zealand in the features measured and the rating method used, even though unsealed roads are not separately measured. It could perhaps be assumed that there are no unsealed roads in England and Wales.

10,900 sites were surveyed by visual observation measuring defects in carriageway, footway and verge. These defects relate to the structural condition visible at the surface and exclude riding quality and skid resistance. The "Defects Index" for each road class is a summary of the carriageway defects, in which the higher the index the worse is the condition.

The index is built up by adding the individual defects weighted by their relative costs of repair at 1986/87 prices. The index is set at 100 for the base year (1977) for each road class. The base year is simply the first for which results are available and does not represent a "standard" or "target". Definitions of individual defects and a fuller description of the index follow, quoted from the publication.

"1. ***Definitions Of Defects***

Most vehicles follow a similar path on a road, resulting in the formation of identifiable wheel tracks. The significance of the wheel tracks is that damage to the road structure, as opposed to superficial damage, is most serious there. In particular, cracking in the area of the wheel tracks may indicate structural damage, especially if associated with the formation of a rut along the wheel track. The results show two wheel track defects:

Wheel-track cracking *and* ***Wheel-track rutting.*** *Wheel-track rutting does not necessarily indicate structural damage if there is no cracking, but it is undesirable because the ruts can hold water. On urban roads pedestrians get splashed and there is a hazard to cyclists and motorcyclists, while on roads with higher speeds there is the risk of vehicles aquaplaning.*

The term "whole-carriageway" does not imply that the whole of the carriageway is affected, but rather that deterioration is not confined to the wheel-tracks. Two degrees of seriousness are reported, defined in detail below.

The definitions in detail are:

Wheel-track Cracking

The average length of cracking present, per 100 metres of road. Wheel-track cracking, if present, is assessed as severity 1 or 2 for each metre of the site for both sides of the carriageway. The measure recorded for the survey is the length of

cracking weighted by severity code. Thus the maximum length is 400 [m] if there is severity 2 cracking along the full length of both sides of a 100-metre site. The method of recording cracking changed for 1983.

Wheel-track Rutting
Average depth of deformation in the nearside wheel track in millimetres.

Whole-carriageway Major Deterioration
The percentage of the carriageway area affected by cracking, coarse crazing or loss of aggregate.

Whole-carriageway Minor Deterioration
The number of 20-metre lengths per 100 metres of road where fine crazing, loss of chippings from surface dressing and some other conditions may call for some remedial treatment.

Edge Deterioration
The length of edge with some degree of deterioration, per 100 metres of edge.

Patching
The percentage of carriageway area consisting of patches or reinstatements. Patching is not strictly a defect since it includes patching that is satisfactory. Failed patching is included also as whole-carriageway major.

Potholes
The number of isolated defects that may be dangerous. The term potholes includes also broken, sunken or upstanding manhole covers, isolated depressions more than 25 mm deep and patches or reinstatements breaking up.

Footway Deterioration
The percentage of footway area with a badly disintegrated or deformed surface, likelihood of standing water, cracked or uneven paving flags or a badly weed-ridden surface.

Footway Trips
The number of spot conditions constituting specific danger to pedestrians.

Verge Deterioration
For grassed verges, the percentage deformed (generally through rutting due to parked or over-riding vehicles). For bituminous verges, the percentage with a badly disintegrated or deformed surface (as for footway deterioration, but with the omission of spot conditions).

Kerb Deterioration
The percentage of kerb length where the kerb needs to be replaced or reset because of spalling, disintegration, broken kerbs, tilting or poor alignment.

Kerb Upstand
Height of kerb upstand in millimetres.

2. ***The Defects Index***
The purpose of the defects index is to summarise the various carriageway defects with a single index that will show trends in condition more clearly than is possible by looking at the defects individually.

The first step is to calculate the total of the defects on each site in the survey. The next step is to calculate the national average of the resulting ratings for each road class. Then finally the national average ratings are converted to indices by dividing by the corresponding ratings in 1977, the base year for the index, and multiplying by 100. The final defects index therefore shows condition relative to a base year rather than as an absolute level.

The defects on a site cannot simply be added together because they vary in importance and because the units vary - some are percentages, some lengths and so on. They have to be converted first to a common measure, and the measure chosen is the notional cost of treating each defect. The costs are based on standard treatments and corresponding standard costs. Defects that are not serious enough to need treatment are costed at an appropriate proportion of the full cost. The absolute level of the costs is not important, as their purpose is to convert defects to a common unit of measurement in the same way each year and in each local authority.

3. ***Calculation Of Results"***
The paper goes on to explain the procedure for working up averages for each item in each road class, placing emphasis on the confidence limits established by statistical methods.

The survey aims to produce comparable averages both locally and nationally, rather than rating individual roads.

Conclusion
While no mention of unsurfaced roads is made in this survey report, possibly because there are none, the features measured and the method of measurement and calculation of defects index could be worth further study and comparison with other methodologies being considered.

Beaven, P.J., Robinson, R., Aklilu, K. 1988. The performance of experimental weathered basalt gravel roads in Ethiopia. ***TRRL Research Report 147.*** **26pp. Transport and Road Research Laboratory, Department of Transport, Crowthorne, Berkshire, UK.**

Reference C27

While this study included measurements of some road elements broadly included under resistance to deformation, rate of loss of gravel and deterioration of roading quality, no measuring and recording system is provided and the purpose of the measurements is to test the performance of a type of aggregate under field conditions.

Although not relevant to this study this paper has been retained for interest, in the *Supplement to Transit New Zealand Research Project No. PR3-0088*, held at Transit New Zealand.

Paige-Green, P. 1990. Some surface roughness, loss and slipperiness characteristics of unpaved roads. First International Symposium on Surface Characteristics of Roadways: International Research and Technologies (W.E. Meyer and J. Reichert, Eds). ***ASTM STP 1031:*** **268-291. ASTM, Philadelphia, Pennsylvania, USA.**

Reference C28

This paper concentrates on roughness and gravel loss prediction and the investigation of slipperiness. It does not contain a recording or measuring system and, although not relevant to this review, has been retained for interest in the *Supplement to Transit New Zealand Research Project No. PR3-0088,* held at Transit New Zealand.

Pienaar, P.A., Visser, A.T. 1992. The evaluation and prioritisation of unpaved road maintenance in developing areas. ***The Civil Engineer in South Africa 34(2) (February 1992):*** **39-49.**

Reference C29

Description

This paper describes, among other matters, a rating system in use in the Republic of Venda and in the self-governing region of Lebowa in South Africa. While designed for roads in poor condition the elements measured are worth noting for this review.

The methodology specifically addresses re-gravelling and betterment needs. The recorded data are used to address a re-gravelling maintenance index (RMI) and a betterment maintenance index (BMI). These indices are expressed in a 5-point scale, in which a value greater than 3 indicates that a project is feasible. Traffic volumes, indicating the number of road users to benefit from any improvements, are also considered when prioritising projects.

Methodology

The elements considered are:

(a) *Gravel surface (wearing course)*
- Loose material
- Dustiness
- Stoniness
- Gravel loss
- Corrugations
- Potholes
- Wet weather trafficability

These are all unpaved road defects except the last which is an indicator of road performance.

(b) *Formation*
- Mitre drains (cutouts)
- Side drains and fill heights
- Protection of drainage structures
- Rock outcrops

These are all roadway elements except the last which is an unpaved road defect.

(c) *Functional Aspects*
- Riding quality
- Skid resistance
- Surface drainage
- Edge condition

Visual evaluations of these aspects are carried out in "Links", ranging in length from 2 km to 5 km, from a moving vehicle travelling at 20-40 km/h, with stops at intervals to determine cover over culverts and wearing course thickness. For Gravel Surface and Formation elements, evaluations are made for both degree and extent, while for Functional Aspects only the degree is evaluated. Degrees and extents are classified in a 5-point scale, the general description of which follow as Tables 1 and 2 copied from the paper.

Zero is used for any aspect not present. A further extensive table details the degree description for each element.

Table 1. Classification of the degree of unpaved road aspects to be evaluated.
(copied from Pienaar and Visser 1992)

Degree	Description
1	Of minor consequence or difficult to discern. No maintenance required.
2	Easily discernible, but of little consequence. No immediate maintenance required.
3	Notable with respect to consequences, but still acceptable. Maintenance is, however, required.
4	Of significant consequences, undesirable. Maintenance required fairly urgently.
5	Of extreme consequence, unacceptable. Immediate maintenance required.

Table 2. Classification of the extent of unpaved road aspects to be evaluated.
(copied from Pienaar and Visser 1992)

Extent	Description
1	Isolated occurrence, i.e. less than 5% of road affected
2	Intermittent occurrence, i.e. between 5% and 15% of road affected
3	Regular occurrence, i.e. between 15% and 30% of road affected
4	Frequent occurrence, i.e. between 30% and 60% of road affected
5	Extensive occurrence, i.e. more than 60% of road affected

Thus all elements are assessed on a subjective visual basis with little or no actual measurements being made. Results are recorded on a form as shown in their Figure 1 (reproduced on p.73 of this report).

GRAVEL ROAD EVALUATION - xxxxx	RATER	DATE	LINK

GRAVEL SURFACE

	SLIGHT --- DEGREE --- SEVERE					SELDOM–EXTENT–EXTENSIVE				
	1	2	3	4	5	1	2	3	4	5
LOOSE MATERIAL										
DUSTINESS										
STONINESS										
GRAVEL LOSS										
CORRUGATIONS										
POTHOLES										
WET WEATHER TRAFFICABILITY										

GRAVEL STRUCTURE

	SLIGHT --- DEGREE --- SEVERE					SELDOM–EXTENT–EXTENSIVE				
	1	2	3	4	5	1	2	3	4	5
MITRE DRAINS										
SIDE DRAINS AND FILL HEIGHTS										
PROTECTION OF DRAINAGE STRUCTURES										
ROCK OUTCROPS										

GRAVEL FUNCTIONAL

RIDING QUALITY	VERY GOOD	GOOD	FAIR	POOR	BAD
	1	2	3	4	5
SKID RESISTANCE	VERY GOOD	GOOD	FAIR	POOR	BAD
SURFACE DRAINAGE	ADEQUATE		CHANGEABLE		INADEQUATE
	1		3		5
EDGE CONDITION	SAFE		CHANGEABLE		UNSAFE

SUMMARY

ATTENTION NEEDED	NONE	STRUCTURE			SURFACING			ROUTINE		
PRIORITY		A	B	C	A	B	C	A	B	C
GENERAL ROAD CONDITION	VERY GOOD	GOOD		FAIR		POOR		BAD		

Figure 1. Gravel road visual evaluation form.
(copied from Pienaar and Visser 1992)

The description of the various degrees of dustiness are of interest for New Zealand conditions, and they are:

Degree 1 Dust just visible through rear window.

Degree 2 Dust easily visible, but not enough to cause driver discomfort, i.e. no need to close the driver's window for approaching traffic, visibility still good.

Degree 3 Notable amount of dust, causing driver discomfort when passing approaching vehicles, visibility acceptable.

Degree 4 Significant amount of dust, visibility reduced to an undesirable level, necessitating a reduction in speed.

Degree 5 Very dusty, surroundings obscured to a dangerous level.

The paper then describes the derivation, by calculation, of the RMI and BMI, both of which are beyond the scope of this review. However one of the early steps is to establish the Urgency Index (UI) which is defined as

$$UI = Degree \times Extent$$

For Functional Aspects the extent is taken as five.

Thus in a scale of 1 to 25 each aspect is given a useful index and a mean of these would give a comparison of the roads and sections they represent. The higher the index, the worse is the road condition.

The paper concludes with a list of steps recommended when applying the complete methodology of the total procedure, and with an appendix describing each aspect being evaluated.

Summary

A useful list of aspects is provided, though not all are applicable to New Zealand conditions. However the method of assessment and the calculation of UI are of interest and could warrant further study for incorporation in the current RAMM manual (Transit New Zealand 1994) procedures.

Thompson, H.W., Rose, D.A., Fanner, S.M. 1989. Establishing priorities for upgrading of gravel roads. ***5th Conference on Asphalt Pavements for Southern Africa:*** **IV-33–IV-42. Manzin, Swaziland.**

Reference C30

This paper establishes priorities on purely economic grounds and does not report any physical measurements on the road. It has been included as it provides another basis for prioritisation, but is not relevant to developing a road condition rating system.

Paige-Green, P., Netterberg, F. 1988. Towards acceptability criteria for unpaved roads. *Transportation Convention, 1988, Paper 20/6.* 15pp. Pretoria, South Africa.
Reference C31

Description
This paper principally compares rating assessments carried out by professional officers with similar assessments made by members of the general public, and lists the results. However in so doing, it lists the aspects evaluated and the scales of assessment. The work was done in Transvaal and South West Africa.

Methodology
As in other South African studies, scales of 1 to 5 are used for severity and extent.
The scale for *severity* is:

1 Excellent
2 Good
3 Average
4 Bad
5 Unacceptable

and for *extent* is:

1 0-20% of area affected
2 20-40% of area affected
3 40-60% of area affected
4 60-80% of area affected
5 80-100% of area affected

The *aspects* assessed are (in sections 300 m long):

Roughness (riding quality)	Gravel loss
Rut depth	Potholes
Corrugations	Surface drainage
Dustiness	Erosion
Looseness	Wet weather trafficability
Stoniness	Slipperiness

The following comment was made on the assessment of dustiness:

> *"As no quantitative measurement of the dustiness was available, the ratings made by the panels were compared with values obtained by the standard method used during the routine monitoring for the project. The rating panels used subjective values on the five-point scale whereas the project used more objective ratings (e.g. Severity 4 - the silhouettes of cars are visible in the dust, while for a rating of 5 a car is totally obscured by the dust at 80 km/h)."*

The paper goes on to compare the results of visual ratings between panels of officials on the one hand and of the general public on the other.

Conclusion

The assessment uses two scales of 1-5 for severity and extent, but no indication is given about what was done with them. Most of the elements are applicable to New Zealand unsealed roads but some clearly are not. This paper reinforces the advantages of using scales or indices rather than individual element measurements in condition rating surveys.

AUSTROADS. 1987. A guide to the visual assessment of pavement condition. First published by NAASRA, 1987, reprinted by AUSTROADS, 1990. *Report AP-8/87 (formerly MEG-11).* 76pp. AUSTROADS, Sydney, Australia.

Reference C32

Description

This publication was not retrieved by the literature search probably because none of the key words appear in the title and it refers to pavement condition on sealed, paved, and concrete roads as well as on unsealed roads. It was however listed as a reference in a reviewed paper, from whence it was retrieved.

While fairly complete with respect to survey methodology, it does not mention inventory or sample lengths, leaving the user to take advantage of the flexibility offered in most aspects of the guide. Its main purpose is to standardise a common reference system for describing the condition of road pavements throughout the states of Australia.

It is intended for use by a pedestrian observer and makes provision for codifying the description and for recording the magnitude of defects.

This review will be confined to that part of the guide concerned with unsealed surfaces, but its introductory comments are common to the whole guide.

Methodology

A strong recommendation is made for visual pedestrian observation of defects to allow for the various effects of moisture and light. A *defect* is defined as the visible evidence of an undesirable condition in the pavement affecting serviceability, structural capacity or appearance. Observation is aimed at identifying a defect and describing its attributes (dimensions and location). Coding of defect descriptions is discussed in detail and while standards are suggested for *severity* (in its Appendix B), the measurement of *extent* is covered by *attributes.*

The following groups of defects are documented by colour photographs using a 1.2 m straightedge to illustrate the depth attribute.

Deformation	**Attributes**
Channel (scour)	Depth, Road length
Corrugations	Max. depth, crest/crest, Road length
Rutting	Max. depth, Road length
Shoving	Depth, Area
Surface Texture	
Coarse texture (stoniness)	Protrusion, Area
Loose material	Thickness, Situation, Road length
Potholes	Depth, Area, Number

Discussion

The helpful, practical appendices define codifying options, the types and requirements of pavement surveys and suggested classifications of severity, based on either a 3- or 5-point system. An example is given of a 3-point classification of defects on bitumen surfaced roads.

The defects assessed are basic and omit the assessment of dust or dustiness. The assessments are inclined to be subjective because of the emphasis on visual estimation but severity classifications are based on actual dimensions, by whatever means they are obtained. "Extent" attributes are codified using actual dimensions rather than indices or classifications.

Conclusion

There is no comment on inventory or sample sections. The defects (elements) assessed are fewer than those listed in the RAMM manual, and no consideration is given to overall shape or drainage. However points to be taken are of the speed of observation because of the limited measuring involved, and of the severity classifications, for possible inclusion in the final RAMM manual. It is a well produced general manual for all types of pavement survey.

3.2 Other Publications

The following publications were also requested from their countries of origin, but were not received.

C20 Transportation Information Center. 1989. *Gravel-PASER manual.* The Transportation Information Center, College of Engineering, University of Wisconsin, Madison, USA.
(Requested 02/06/93 but it is unobtainable in the USA)

C22 Visser, A.T. 1985. Review of the use of maintenance and design systems for managing unpaved road networks. *Paper 2B/14.* TRRL, London, UK.
(Requested 03/05/93 but apparently unobtainable in SA or UK)

While Reference C22 may not have been of much significance to the research recorded in this report, the Gravel-PASER manual (Reference C20) may have been of considerable importance.

4. SUMMARY

The summary (Table 4.1) lists the 17 publications identified in Section 3 of this report that warrant further investigation for their applicability for road condition rating of unsealed roads in New Zealand. The table summarises the features of each publication and identifies the important aspects of each one.

Each item can be identified by its reference number, e.g. C1. These reference numbers are used throughout the report.

The brief name of each publication used in Table 4.1 consists of the kind of report (e.g. manual, guideline, paper, report), and the country in which it is sourced. For full references of the publications (in alphabetical order) see Section 7 of this report.

Table 4.1 Summary of systems, and their features, that are recommended for further investigation.

Ref	Name, Country	Complete Rating System	Guidelines Only	Computer Based	Road Section Methodology	Condition Measurements																				Subjective Measures	Objective Measures	Treatment Link	Possible NZ Application
						Deformation	Corrugations	Rutting	Shoving	Potholes	Drainage	Gravel Loss	Safety	Loose agg.	Dust	Crossfall	Shoulders	Cracks	Roughness	Gravel depth	Stoniness	Clay	Washouts	Rideability	Scour	Agg Typicie				
C1	ARRB Manual, Aust.		Yes	?	Yes	*	*	*	*	*	*		*											*			Yes	Yes	Yes	Yes
C2	MOT Manual, Canada	Yes		?	Yes	*	*	*	*	*				*	*	*	*	*									Yes	Yes	Yes	Yes
C5	Report 87–15, USA	Yes		Yes	Yes		*	*		*	*			*	*	*												Yes	No	Yes
C10	Paper, Aust.		Yes																											Some
C12	PIARC Report, Finland	Yes		Yes	No		*	*		*				*	*	*	*	*	*		*						Yes	?	Some	Yes
C14	Report, Finland	Yes		Yes	Yes									*					*	*								Yes	Yes	Unlikely
C16	PMS Guidelines, Aust.		Yes	Yes	?	*	*	*	*	*				*					*					*				Yes	Yes	Yes
C17	OECD Manual, USA	Yes		Yes	Yes		*	*		*						*				*		*	*					Yes	Some	Yes
C18	Report, USA		Yes	?	?		*	*		*	*			*					*					*			Yes		?	Some
C19	Paper, Aust.		Yes	?	?														*					*					Yes	Some
C23	PASER Manual, USA #	Yes		Yes	Yes																						?	?		#
C24	RAMM Manual, NZ	Yes		Yes	Yes		*	*	*	*	*			*		*									*	*		Yes	No	Yes
C25	Far North PMS, NZ	Yes		Yes	Probably		*	*	*	*	*			*		*									*	*		Yes	Yes	Yes
C26	DOT survey, UK	Yes		Yes	Probably			*		*								*									Yes		Yes	Unlikely
C29	Paper, Venda SA	Yes		Yes	Yes		*			*	*	*		*	*						*			*			Yes		Yes	Yes
C31	Paper, Transvaal SA	Yes		?	?		*	*		*	*			*	*												Yes		?	Some
C32	Austroads guide, Aust.	Yes		Yes	No	*	*	*	*	*				*							*				*		Yes		No	Some

#	PASER Manual not received by 31 January 1995		
Ref.	Reference number used in this report		
Aust.	Australia	Maint.	Maintenance
Managt	Management	Agg.	Aggregate

5. CONCLUSIONS

5.1 Selecting Systems for Further Study

This literature search has identified seventeen publications detailing systems proposed or used for condition rating of unsealed roads that could warrant further investigation for two reasons: their applicability to unsealed road requirements in New Zealand, and their compatibility with the operational RAMM system used in New Zealand. Of the seventeen publications referred to:

- six are existing systems in use
- ten are proposals and guidelines
- one was unavailable in its country of origin

Three of the existing systems and three proposals have been selected for further discussion. Except for the Finnish system, all appear to use a road inventory methodology similar to the RAMM system.

Clearly one of the issues evident from the literature covering condition rating of unsealed roads is the dynamic nature of the asset condition and the number of condition variables. The concept of an annual condition rating survey, as currently carried out for sealed roads, will only hold true for unsealed roads where the distress measurements truly reflect the condition of the asset on an annual basis for planning purposes.

Seasons, climate and materials can all combine to produce a number of different unsealed road conditions in any one year. Such effects will influence not only the selection of distress variables to measure but also the frequency and timing of the measurements. Further detailed evaluation of existing systems will relate to the outcome intended from an unsealed road condition rating survey. Identification of this outcome and detailed investigation of the systems identified as warranting further attention would be the next stage of this project.

The shortlisted systems from overseas have three things in common:

- Elements are evaluated on a 5-point scale, not measured in units or percentages.
- All evaluate by degree/severity, and some by density/extent as well.
- Rating results may be used to prioritise needs.

None of these features are included in the New Zealand systems. Only corrugations and potholes are common to all the selected systems, and dust is not included in the New Zealand, Finnish and OECD systems.

The concept of rating, while including survey or assessment of present condition, also covers grading or placement in order (ranking). Rating systems should therefore be expected to produce a ranking of the sections surveyed. All the overseas systems do this but the New Zealand systems do not.

For the purpose of ranking the six selected systems, the RAMM and FNDC systems have been considered together. The aspects measured are the same and, while the FNDC paper does not give any survey details but concentrates on reports of condition based upon those data, the RAMM manual gives finely detailed instructions on measurement taking but goes no further.

The AUSTROADS national guide has not been included in the short list mainly because of the few defects (elements/aspects) that are assessed. However its appendices contain some useful guidelines in codifying and indexing which could be most helpful in progressing, or recommending further output from, the existing RAMM System.

Many of the systems reviewed have transferred field measurements to numbers, thus enabling the flagging of sections whose overall condition requires action. It should be more cost-effective to attend to all the elements in a section, rather than dealing with only the one element in all sections, at one time.

As units of measurement are different for individual elements, ranging from number to length and area, each must be reduced to an index number. Then the indices must be meaned or summed to get the value for the length and consequently the section of road.

The shortlisted papers are reviewed in detail in Section 5.2 of this report with respect to the aspects assessed and the data produced. While the reviewed papers do not always make this point, the usefulness of any system relies heavily on an accurate inventory and careful selection of fully representative evaluation/inspection sections.

5.2 Studies of the Selected Systems

5.2.1 Manual, Canada (Chong and Wrong 1989) Reference C2

A proposal only at time of its publication (1989).

Roadway surface and shoulder distress manifestations.
(See Figure A-1 in Chong and Wrong 1989, reproduced on p.22 of this report.)

Elements Measured	**Method of Measurement** for all elements:	
	Severity	*Density*
Surface Defects - Loose gravel - Dust - Potholes - Break up	Slight, moderate or severe with a detailed scale for each element	Intermittent = < 20% of surface affected
Surface Deformation - Corrugations - Rutting - Flat or reverse crown - Distortion (depression, shoving, frost heave, etc.)		Frequent = 20-50% of surface affected
Shoulder Distresses - Excessive height - Ponding - Overgrowth		Extensive = > 50% of surface affected

Pavement condition rating (PCR) is assessed on a scale of 1–100 for each section of road taking into account the severity and density of the various elements as listed in Table B-1 (reproduced on p.23 of this report).

Further action is recommended for each combination of severity and density for each element.

However by ranking the PCRs, priorities can be set for maintenance works based on the overall condition of the individual roads or sections.

See also pp. 20-25 in Section 3 of this report.

5.2.2 Special Report 87-15, USA (Eaton et al. 1987a) Reference C5

This manual appears to have been a proposal when it was published in 1987, rather than a report on an existing system.

Element Measured	Method of Measurement (units of low, medium and high severity)
Improper cross section	Length m
Inadequate roadside drainage	Length m
Corrugations	Area m^2
Dust	Severity only
Potholes	Number
Ruts	Area m^2
Loose aggregate	Length m

(NB: the report used imperial units)

The result is expressed as an Unsealed Road Condition Index (URCI).

Calculating the ratings

The distress measurements are used to calculate the URCI based upon deduct values. A deduct value is a number from 1 to 100 where 0 means the distress has no impact and 100 means the road has failed. The procedure for calculating ratings is outlined on p.30 of this report.

See *Appendix C to Transit New Zealand Research Project No. PR3-0088* (held at Transit New Zealand, Wellington) for Reference C5 for graphs of curves.

See also pp. 28-31 in Section 3 of this report

5.2.3 PIARC Report, Finland (Isotalo 1987) Reference C12

A simple subjective assessment on a scale of 1 to 5 of the wearing course (riding surface) condition based on the elements listed on pp.38-39 of this report.

This system used in Finland is part of a complete maintenance management system. A trigger level of 2.5 is set and the optimum is about 3.4.

Comparisons can be made between roads and districts, and work prioritised. An interesting comment in this paper says *"gravel roads, contrary to paved roads, need constant caretaking and various maintenance measures".*

See also pp. 38-40 in Section 3 of this report.

5.2.4 OECD Manual, USA (OECD 1990) Reference C17

This proposal incorporates a two level inspection system. The first, Road Condition Survey (RCS), is carried out annually over the entire network (presumably as represented by inspection sections). The second, Detailed Visual Inspection (DVI), is repeated at least over those sections identified by RCS as requiring major maintenance.

In the RCS the classification of the carriageway or road surface condition is made on a 5-point scale, based on the following table:

Condition Rating	Maintenance Activity required - "Unpaved Roads"
1 = excellent; no damage visible	No action required
2 = good	No immediate action required
3 = fair	Dragging and/or grading; in some cases the processing of the base course may be required
4 = critical	Processing of existing base course and/or adding of gravel/selected material necessary
5 = failed	Adding gravel or selected material and processing of base course

Note: In general, a rating of 3 or higher implies that a DVI is required to reveal the proper type of maintenance activity required.

In addition to the damage affecting the road surfacing, the inspectors also evaluate the defects and damage of the drainage system and the area adjacent to the road (e.g. fill). This is done with a 3-point rating system for roadside elements, road signs and furniture and structures in accordance with the description given on the relevant damage sheet.

The principles of this 3-point system (se table below) are that the values recorded for each element reflect the efficiency of routine and recurrent maintenance activities. The need for immediate intervention is based on considerations relating to road user safety and the stability of the road, embankment and structures.

Rating Criteria		
Value	**Routine Maintenance**	**Action**
1	Satisfactory	Not necessary
2	To be checked	To be expected shortly
3	Not Satisfactory	Necessary

The DVI is the more relevant survey which measures the following elements:

Rutting	
Corrugations	Erosion gullies
Camber/crossfall	Potholes
Gravel thickness	Clay

Each of these elements is measured for extent and severity. An example is given in the following table for corrugations, where depth of the hollow (Severity) is measured from a 2 m straightedge placed across the top of adjacent ridges, and the class is derived from this measurement.

Evaluation					**Class** Severity		
	Extent	Severity			1	2	3
1	< 10%	< 20 mm		1	1	3	4
2	10-50%	20-50 mm	Extent	2	2	3	5
3	> 50%	> 50 mm		3	3	4	5

Tabulation taken from Volume 2 (OECD 1990).

The extent is plotted against severity and the class is derived. Other elements are similarly evaluated to give a class in a 1- to 5-point scale. Appropriate forms are provided for each element for each level of survey.

DVI is not used regularly but only where indicated by the RCS. The classes indicated by each element form are totalled and meaned for the section from which length-weighted means can be obtained for roads or districts, etc. The interpretation of the means can be used to prioritise works and to decide whether the need is short or medium term.

See also pp.48-50 in Section 3 of this report.

5.2.5 Gravel-PASER Manual, USA (Walker 1991) Reference C23

This paper by Walker promotes the PASER manual. Unfortunately the Gravel PASER manual (Transport Information Center 1989) is unavailable in the USA, its country of origin.

However the elements measured are quoted in Walker's paper and are worth recording here:

Element	Evaluation
Crown	
Drainage	
Gutter depth	On a scale of 1-5
Washboarding (Corrugations)	See below
Potholes	
Rutting	
Dust	
Loose aggregate	

A simplified 5-point rating scale has been developed. Each category is intended to indicate conditions directly related to the need for maintenance or rehabilitation. The ratings may be considered as follows:

5	(Excellent)	A newly constructed road. Excellent crown, drainage, and gravel layer.
4	(Good)	Recently regraded with good crown and drainage, and adequate gravel layer.
3	(Fair)	Needs routine regrading or minor ditch maintenance.
2	(Poor)	Needs additional aggregate or major drainage maintenance.
1	(Failed)	Complete regrading required.

The rating scale is discrete, and other ratings (2.5 for example) are not encouraged.

Table 1 from Walker's paper (and copied on pp.90-91 of this report) contains a description of the individual ratings with the typical distress and recommended maintenance or rehabilitation procedures.

See also p.56 in Section 3 of this report.

Table 1. Rating system in PASER manual system.

(copied from Walker 1991)

Surface Rating	**Visible Distress***	**General Condition/ Treatment Measures**
5 Excellent	No distress	New construction - or total reconstruction
	Dust controlled Excellent surface condition and ride	Excellent condition Little or no maintenance needed
4 Good	Dust under dry conditions	Recently regraded
	Moderate loose aggregate	Good crown and drainage throughout. Adequate gravel for traffic.
	Slight washboarding	Routine maintenance may be needed
3 Fair	Good crown (3" - 6")	Shows traffic effects
	Ditches present on more than 50% or roadway	Regrading (reworking) necessary to maintain
	Gravel layer is mostly adequate, but additional aggregate may be needed at a few locations to help correct washboarding or isolated potholes and ruts	Needs some ditch improvement and culvert maintenance Some areas may need additional gravel
	Some culvert cleaning needed	
	Moderate washboarding (1"-2") over 10% - 25% of the area	
	Moderate dust, partial obstruction of vision	
	No or slight rutting (less than 1" deep)	
	An occasional small pothole (less than 2" deep) Some loose aggregate (2" deep)	

Table 1 continued:

Surface Rating	Visible Distress*	General Condition/ Treatment Measures
2 Poor	Little or no roadway crown (less than 3")	Travel at slow speeds (less than 25mph) is required
	Adequate ditches on less than 50% of roadway. Portions of the ditches may be filled, overgrown and/or show erosion.	Needs additional new aggregate Major ditch construction and culvert maintenance also required
	Little or no aggregate Some areas (25%) with culverts partially full of debris	
	Moderate to severe washboarding (over 3" deep) over 25% of area	
	Moderate rutting (1"-3"), over 10%-25% of area	
	Moderate potholes (2"-4"), over 10% - 25% of area	
	Severe loose aggregate (over 4")	
1 Failed	No roadway crown or road is bowl shaped with extensive ponding	Travel is difficult and road may be closed at times
	Little if any ditching	Needs complete rebuilding and/or new culverts
	Filled or damaged culverts	
	Severe rutting (over 3" deep) over 25% of area	
	Severe potholes (over 4" deep) over 25% of area	
	Many areas (over 25%) with little or no aggregate	

*Note: Individual roadways may not have all the types of distress listed for any particular rating; they may have one or two types.

This proposed system will thus produce ratings of 1–5 for each element in each inspection section of a road. Although not defined in the paper, presumably this rating can be summed or meaned, length-weighted and used to prioritise works based on overall requirements. Note however that the higher the rating the better the road, contrary to some other systems.

5.2.6 RAMM Manual, New Zealand (Transit New Zealand 1994) Reference C24

This system is in operation in New Zealand and was designed by Beca, Carter, Hollings and Ferner Ltd, some of whose staff was also involved in developing a system for the FNDC in New Zealand (C25).

Individual elements are measured and recorded in this system as follows:

Element	Method of Measurement
Potholes	Numbers in each of 12 classes.
Improper cross section	Measured at ¼ and ¾ points in each inspection length - number of ½ widths with < 5% slope per length
Scour	Area in m^2
Shoving	Length of wheel path in m
Rutting	Length of wheel path in m
Corrugations	Area in m^2 of two classes
Loose aggregate	Measured at ¼ and ¾ points in each length as length of windrow in each of two depths
Aggregate topsize	Average topsize of running course aggregate as either 20, 40 or 60mm
Surface water channels	Length on both sides of road for full rating section of 'blocked' and 'inadequate' channels

The omission of dust from this list of elements is noteworthy.

This system records existing road conditions in considerable detail. However unless some form of index is available, the only indication of need of action would be confined to elements having a value in excess of a pre-set trigger value.

The system does not presume to entail anything more than data gathering but the use to which the data are to be put must control, at least to some extent, the form of the data put into the system.

See also pp.57-61 in Section 3 of this report.

5.2.7 Far North PMS, New Zealand (Hallett & Jacobson 1994) Reference C25

This is an operative system developed by Beca, Carter, Hollings & Ferner Ltd. Although a recording system is not described, the elements are listed and, because trigger levels are described, the units of measurement can be derived. They are:

Element	**Units of Measurements** (50 m of each 500 m section)
Loose aggregate (including agg. topsize)	m of windrow average depth of 50 mm or more
Corrugations	m^2 of corrugation deeper than 75 mm
Improper cross section	% of length with crossfall less than 5%
Potholes	Number
Rutting	m
Shoving	m
Drainage (over whole 500 m length)	% inadequate and blocked water channels
Water scour	Area m^2

The trigger levels set in the reporting scheme activate maintenance for each individual element. There is provision to link drainage problems with rutting, shoving and scour, and also to link improper cross section with surface distress such as potholes, rutting and shoving.

See also pp.62-65 in Section 3 of this report.

5.2.8 Paper, Venda - Lebowa, SA (Pienaar & Visser 1992) Reference C29

This existing system specifically addresses the area of regravelling and betterment of unsealed roads and was used on 66 sections of unpaved roads in the Republic of Venda and the self-governing region of Lebowa, South Africa.

The aspects observed visually are:

(a)	*Gravel Surface (wearing course)*	
	Loose material	Corrugation
	Dustiness	Potholes
	Stoniness	Wet weather trafficability
	Gravel loss	
(b)	*Formation*	
	Mitre drains	Protection of drainage structures
	Side drains & fill heights	Rock outcrops
(c)	*Functional Aspects*	
	Riding quality	Skid resistance
	Surface drainage	Edge condition

Each aspect is evaluated on a scale of 1-5 for both degree and extent. The UI is calculated as the product of degree and extent. The UI, on a scale of 1-25, gives a convenient prioritisation of maintenance needs in which the higher the UI the greater the need.

See also pp.71-74 in Section 3 of this report.

5.3 Ranking the Six Best Systems

All the overseas systems studied use a 1–5 scale to evaluate degree/severity and some use an extra 1–5 scale for extent/density. They do not involve the degree of accurate measurement featured in the RAMM manual (Transit New Zealand 1994). As these forms of evaluation are mainly subjective, the objective approach used in New Zealand's RAMM system is favoured. The RAMM system is therefore ranked first in association with the FNDC system (Hallett and Jacobson 1994).

The FNDC system is also favoured, largely because it indicates a form of outcome. This outcome is the triggering of reports when the value of individual elements falls below a pre-set measurement and action is required on that element. While that outcome is not particularly favoured because it refers to action on one element rather than on a section of road, it could be developed to produce information on sections of road requiring action.

Table 5.1 ranks the six systems favoured, all of which are identified in Sections 3 and 5.1 of this report to warrant further investigation of their applicability for rating unsealed road condition in New Zealand. The ranking is dependent more upon the lists of elements observed than on other considerations, as all the overseas systems use the 1–5 scales. No distinction has been made between existing and proposed systems.

Table 5.1 also summarises the features of each system and its most important aspects. Each system is identified by its reference number, e.g. C1.

The brief name for each publication used in Table 5.1 consists of the kind of report (e.g. manual, guidelines, paper, report), and the country in which it is used. For full references of the publications (in alphabetical order) see Section 7 of this report.

Table 5.1 Short list of systems recommended for further study, ranked in order of preference.

Ranking	Ref No	Name, Country	Existing or Proposed System	Relevant Condition Measurements																					Suitable for Prioritisation	Measurement	Degree/ Severity	Density/ Extent
				Deformation	Corrugations	Ravelling	Shoving	Potholes	Drainage	Gravel loss	Loose Agg.	Dust	Crossfall	Shoulders	Cracks	Roughness	Gravel depth	Stoniness	Clay	Washout	Rideability	Scour	Agg. Topsize	Edges				
1 (	C24	RAMM Manual –	Existing		•	•	•	•	•		•		•									•	•		No	Yes	No	No
(	C25	Far North PMS, NZ	Existing		•	•	•	•	•		•		•			•						•	•		No	Yes	No	No
2	C2	Manual, Canada	Proposed	•	•	•	•	•			•	•		•	•										Yes	No	Yes	Yes
3	C5	Report 87–15, USA	Proposed		•	•		•	•		•	•	•												Yes	No	Yes	No
4	C29	Paper, Venda, SA	Existing		•	•			•	•	•	•						•			•			•	Yes	No	Yes	Yes
5	C17	OECD Manual, USA	Proposed		•	•		•					•				•		•	•		•			Yes	No	Yes	Yes
6	C12	PIARC Report, Finland	Existing		•	•		•			•		•		•	•		•							Yes	No	Yes	No

Ref.No. Reference number used in this report

6. RECOMMENDATIONS

6.1 Improving the RAMM Manual

Any further study should concentrate on improving the usefulness of Part II of the *RAMM Unsealed Road Condition Rating Standards* manual (Transit New Zealand 1994; Reference C24) rather than seek to replace it with another system. The approach using accurate measurement of elements is considered to be the correct one. However a method should be devised that codifies or converts the results of those measurements to an index, which enables work to be done to be prioritised. While, with computer assistance, it should be possible to analyse these results and sort them in priority of need, this is not made clear in the RAMM manual.

The FNDC system (Hallett and Jacobson 1994; Reference C25), which groups some elements and provides trigger levels for their combined condition, goes some way towards prioritising needs by analysing results. However, it still tends to be confined to individual aspects needing attention, rather than to sections of roads as a whole. Dealing with more than one aspect requiring attention at one visit should be more cost-effective than dealing with defects in one feature, district-wide at one time.

The key to successful rating surveys lies in the accuracy of the asset inventory and the selection of inspection lengths. The RAMM system is the most appropriate for New Zealand conditions and should be retained for this reason. Many of the reviewed systems incorporated the selection of rating sections, but many did not. None of those examined appeared to offer more than the RAMM system in this respect.

However the need to record twelve different sizes of potholes in the RAMM system is questioned.

Recommendation: Retain Part II of the *RAMM Unsealed Road Condition Rating Standards* manual with respect to inventory, sampling, and methods of measurement.

6.2 Additonal Elements for Assessment

Dust: The elements measured in the RAMM manual are appropriate but one noteworthy omission is dust or dustiness. While dust causes definite problems with visibility for road users, its greatest disadvantage in New Zealand is the damage caused to roadside horticultural production. While some publications express the difficulties in measuring dust production, a case exists for subjective assessment of this element, and they give some assistance in this assessment. Perhaps the best approach might be to design a 1–5 scale of the negative effect of dust on agriculture (and hence on the national economy), rather than measuring the dust itself.

In Section 3 of this report, Reference C29 includes a 5-point scale for assessing degree of dustiness, Reference C2 includes guidelines for 3-point scales for both severity and density of dust, and Reference C5 includes a 3-point scale for severity of dust. There are, probably, other scales which could be considered.

Aggregate loss: This is another element which should be measured and included in the RAMM manual, and its effect measured as a direct economic cost in re-metalling.

Although it is the direct economic benefit of dust on agriculture and horticulture that should be targeted, physical dust loss is also a measure of aggregate loss.

Recommendation: Include, in the RAMM manual Part II, the elements of dust and aggregate loss.

6.3 Index Numbers for Outputs

Several methods retrieved in the literature search describe how indexing can be achieved, but the index should rely on the field measurements that are already being taken. Both degree/severity and extent/density should be considered in setting an index number even if some modification of the field measurements is needed.

Apart from using individual details from the overseas literature as recommended above, any further consideration of overseas systems is not considered to be necessary. However it is recommended that a separate study is undertaken to design a suitable index system and, to reiterate, this depends almost solely on the output expected and its potential uses.

The AUSTROADS manual (1987, reprinted 1991) is helpful in converting measurements to index numbers and its precepts should be followed to implement this in any system developed for New Zealand roads.

By the use of index numbers for each element, the overall condition rating for each sample unit can be assigned by a number from a mean or sum of the individual indices. Thus the road section represented by the sample units can be prioritised for maintenance work. This prioritisation is not possible while measurements of elements are being recorded in a variety of units (length, area, number, etc.).

Prioritisation is also facilitated by including AADT and roughness in the final figures. AADT is used to evaluate the benefits for any expenditure and later to ensure that an overall standard appropriate to the road user is being achieved.

With all aspects of the condition rating coming forward as a number, comparisons may be made between sections, roads, and districts to determine priorities for maintenance.

Recommendation: In the RAMM manual, include index numbers as outputs on all the elements to be assessed, to enable prioritisation of works to be facilitated.

7. REFERENCES

C1, C32, etc. Reference numbers used in this report
Publications obtained are held at Transit New Zealand as *Appendix 3* and *Supplement to Transit New Zealand Research Project No. PR3-0088.*
C20*,C22* Publications not obtained
— Publication not evaluated

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