SURVEY OF NEW ZEALAND ROADING AUTHORITIES REGARDING PAVEMENT ENGINEERNG ISSUES

Transfund New Zealand Research Report No. 143

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AN IMPORTANT NOTE FOR THE READER

The research detailed in this report was commissioned by Transfund New Zealand.

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EXECUTIVE SUMMARY

The objective of this project was to identify the issues regarding pavement engineering that are currently important to New Zealand roading practitioners. The identification of these issues provides guidance on where future research should be focused to achieve maximum benefit. In addition, the project sought information on unique or innovative practices that may be of interest to the roading fraternity in general.

This report presents the results of a survey of New Zealand's Territorial Authorities, Transit New Zealand and selected Industry Organisations on pavement engineering issues. The survey was carried out in 1998 using a questionnaire that was designed to determine which areas of pavement engineering require further research in the near future.

The main conclusions that can be drawn from the project are as follows:

- The perception of the majority of the respondents regarding the status of the pavement engineering situation in New Zealand is reasonably positive. Most respondents indicated that the quality of their roading networks is increasing, pavements generally achieve their intended design lives, and maintenance costs are acceptable.

- When premature failures do occur, the main contributing factors have been identified in general to be increased loadings, construction problems, materials problems, adverse environmental conditions, and inadequate design. Each of these factors was assigned approximately equal weighting by the respondents. The main modes of pavement failure are generally (in decreasing order of frequency) cracking, rutting, pot-holing, edge defects, shearing and formation of corrugations.

- Having concluded that the quality of New Zealand's roading networks is generally increasing, there is recognition that further research is nevertheless required. A number of potential research topics have been presented.

- The involvement of Territorial Authorities in pavement engineering research that is funded by themselves or by the state is reasonably limited.

- While the acceptance of state-funded research programmes appears to be quite high, most respondents qualified their response regarding the relevance and timely implementation of the research findings.

- Territorial Authorities receive virtually no benefit from state-funded research programmes except those promoted by Transfund (and formerly Transit) New Zealand.

- Irrespective of Transit New Zealand's adoption in 1995 of the AUSTROADS pavement design procedures, a number of Territorial Authorities do not use, or do not require the use of, the AUSTROADS procedures.

- The use of so-called marginal aggregates has received moderate support by Territorial Authorities. Most of the respondents who do use marginal aggregates caution that the materials generally require improvement by some means, e.g. lime/cement/KOBM stabilisation and / or blending with superior materials. The importance of drainage is also stressed. The appropriate use of marginal materials is a topic that deserves further research in the near future as the resources of premium aggregates become depleted.

- A small number of unique or innovative practices have been obtained from respondents and these are listed in the report. A relevant research objective would be to investigate some of these practices to ensure that they can be used successfully throughout New Zealand.

ABSTRACT

This report presents the results of a survey of New Zealand's Territorial Authorities, Transit New Zealand and selected Industry Organisations on pavement engineering issues. The survey was carried out in 1998 using a questionnaire that was designed to determine which areas of pavement engineering require further research in the near future.

The report presents a number of potential pavement engineering research topics that have been identified by the respondents. It also describes various perceptions and attitudes held by the respondents on issues such as the effectiveness of current state-funded research programmes, the adequacy of pavement design procedures, factors influencing pavement performance, the use of marginal aggregates, and the types and performance of pavement surfacings.

The respondents were also asked to provide information on any unique or innovative pavement engineering practices that may be of interest to the roading fraternity in general.

1. INTRODUCTION

1.1 General

Roads and highways represent a significant asset to a community both financially and socially. Therefore, it is essential that road pavements are designed and built to provide a high level of service for their intended use over the period of their expected life. To achieve this objective the best available engineering procedures and practices must be employed. Research and development is the tool that is used to improve both the quality and the efficiency of pavement design, construction and management procedures.

While research and development is an important aspect of any industry, it is essential that the research effort is directed at resolving relevant issues. Furthermore, the results of the research must be implemented in a coherent and timely manner so that the ensuing benefits can be realised as soon as possible.

1.2 Objective

The objective of this project was to identify the issues that are currently important to New Zealand roading practitioners, i.e. the people who plan, design, build and manage pavements on a daily basis. The identification of these issues provides guidance on where future research should be focused to achieve maximum benefit. In addition, the project sought information on unique or innovative practices that may be of interest to the roading fraternity in general.

1.3 Project Strategy

The objectives stated in Section 1.2 were achieved using a questionnaire to canvass asset managers from New Zealand's roading authorities, i.e. the 86 Territorial Authorities and Transit New Zealand's Head and Regional Offices. In addition a small number of Industry Organisations were included to gain an alternative perspective. A complete listing of organisations invited to participate in the survey is presented in Appendix A of this report.

Most questionnaire-based research suffers from a low response rate. All efforts were made to achieve a high redemption rate in this project. To achieve this, the following strategy was used:

- the questionnaire was developed to be simple and reasonably quick to complete;
- the questionnaire included lists of standardised responses where appropriate;
- an advance letter was sent to all respondents explaining the objectives of the project;
- postage paid and return addressed envelopes were provided with the questionnaires; and
- an attractive reward was offered as an incentive for timely responses.

2. SURVEY QUESTIONNAIRE

2.1 Development of the Questionnaire

The survey questionnaire was developed by Bartley Consultants Limited. A copy of the questionnaire is presented in Appendix B of this report.

The main consideration in the development of the questionnaire was to produce a document that was simple and reasonably quick to complete while still giving the respondent sufficient freedom to provide objective and open-minded answers. This requires something of a compromise between setting multiple-choice type questions, which are simple to answer but can be restrictive, and conversely setting open-ended questions which may be poorly understood and time-consuming to complete.

The questionnaire was divided into five sections, i.e.

- Background Information;
- Pavement Engineering Research;
- Pavement Design Issues;
- Pavement Performance; and
- Pavement Construction, Rehabilitation and Maintenance.

2.1.1 Background Information

The *Background Information* section comprised a matrix of pavement engineering related functions. The respondents were asked to indicate which tasks (if any) were carried out by their organisation in-house and which tasks (if any) were let to external contractors. The objective of this question was to provide general information that may assist in the interpretation of responses to questions in the succeeding sections of the questionnaire.

2.1.2 Pavement Engineering Research

The *Pavement Engineering Research* section comprised eleven questions inquiring into the level of involvement in research of each organisation. It also included one of the key questions in the questionnaire regarding areas of pavement engineering that the respondents consider to require research in the near future. The objective of the section was to gauge the general attitude to the effectiveness of current research programmes, and to determine where future research efforts may be best served.

2.1.3 Pavement Design Issues

The *Pavement Design Issues* section comprised five questions inquiring into the design procedures used by the organisation and information on pavement loading issues. The objective of this section was partly to gauge whether the recent (1995) adoption in New Zealand of the AUSTROADS pavement design procedures (AUSTROADS 1992, Transit New Zealand 1998) has resulted in the need for further research. Another objective was to investigate the trends in pavement loadings and whether this issue is significant for future research purposes.

2.1.4 Pavement Performance

The *Pavement Performance* section comprised four questions inquiring, where applicable, into the quality of the organisation's roading network, the predominant modes of pavement failure and the factors that contribute to pavement failures. The objective of this section was to identify if there are in fact serious problems that require research, and if so, in what general areas of pavement engineering these problems are occurring.

2.1.5 Pavement Construction, Rehabilitation and Maintenance

The *Pavement Construction, Rehabilitation and Maintenance* section comprised eight questions inquiring into acceptability of maintenance costs, types and performance of pavement surfacings and the use of so-called marginal aggregates in construction. It also solicited information regarding unique or innovative practices developed by the organisation. The objective of this section was to determine in what areas of construction, rehabilitation and maintenance further research may be appropriate.

2.2 Distribution and Response

A total of 97 questionnaires were delivered to selected organisations within the New Zealand roading fraternity. A period of two months was allowed for filling out and returning the questionnaires. At the end of that period replies had been received from 55 respondents. This response rate (57%) was considered to be reasonable considering that a number of the Territorial Authorities included in the survey have a very limited roading involvement.

Figure 2.1 shows a summary of the types of organisations that were sent questionnaires (a), and the rates of response for each organisation type (b).

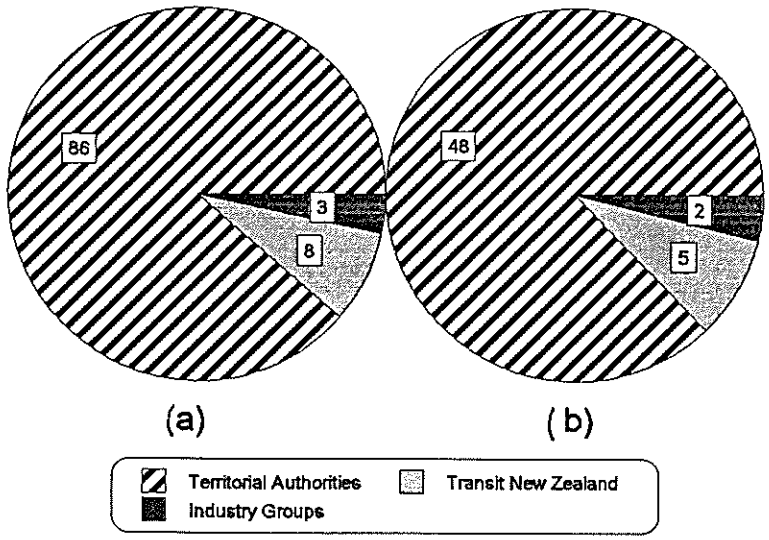

Figure 2.1 Summary of types of organisations sent questionnaires (a), and numbers of responses (b).

3. QUESTIONNAIRE RESPONSES

3.1 Background Information

Table 3.1 summarises the responses obtained for the *Background Information* matrix. It shows the percentage of organisations that perform each of the identified pavement engineering functions on either in-house or external bases. Note that In-house and External functions do not necessarily add up to 100%, because many functions can be carried out both in-house and externally.

Table 3.1 Summary of background information data.

Function	Percentage of Organisations Performing Functions					
	TAs (49 Responses)		Transit / TNZ (4 Responses)		IOs (2 Responses)	
	In-house	External	In-house	External	In-house	External
Pavement Management	83	13	75	100	0	0
Network Planning / Policy	93	13	75	100	0	0
Geometrical Design	61	54	0	100	0	0
Pavement Structural Design	59	57	0	100	50	100
Pavement Rehabilitation Design	59	54	0	100	50	100
Pavement Condition Surveys	9	85	0	100	0	0
Transportation Studies	20	74	0	100	0	0
Safety Audits	46	74	50	100	0	0
Materials Testing	11	85	0	100	0	100
Pavement Construction	2	89	0	100	50	100
Seal Extensions	9	85	0	50	0	50
Maintenance (Sealed)	4	91	0	100	50	100
Maintenance (Unsealed)	9	85	0	50	50	50
Contract management	74	59	75	100	0	50
Other	9	2	0	0	0	0

TAs : Territorial Authorities
Transit/ TNZ : Transit New Zealand / Transfund New Zealand
IOs : Industry Organisations

3.2 Pavement Engineering Research

The Pavement Engineering Research section investigated the involvement and attitudes to current and future research by the various organisations. It also investigated the means by which organisations become aware of research findings. The results are summarised in Tables 3.2 and 3.3.

Table 3.2 Participation in and use of pavement research.

Inquiry	Research Funding	TAs	Transit / TNZ	IOs
Proportion of organisations performing their own research	Own	22%	75%	100%
Proportion of organisations with current or previous involvement in state-funded research	TNZ	11%	75%	100%
	FSRT	0%	0%	100%
	University	0%	25%	100%
Proportion of organisations directly utilising state-funded research findings	TNZ	40%	75%	100%
	FSRT	0%	0%	100%
	University	2%	25%	100%
Proportion of organisations recognising the need for further research	n/a	67%	75%	50%

TAs : Territorial Authorities
Transit/TNZ : Transit New Zealand / Transfund New Zealand
IOs : Industry Organisations
FRST : Foundation for Research Science & Technology

Organisations that have conducted their own pavement engineering research projects indicated that the following topics have been the focus of their research:

- stabilisation in pavement rehabilitation, including Endurazyme;
- skid resistance of surfacings;
- pavement reinforcement using grids and fabrics;
- dust suppression;
- design of pavements on volcanic subgrade soils;
- unsealed road maintenance, including wearing course materials, grading and cross-falls;
- bitumen safety issues;
- review of chipseal design procedures;
- laboratory testing of elastic parameters for New Zealand asphalt mixes;
- ultra-thin white topping.

Table 3.3 Means of obtaining pavement research results.

Means of Obtaining Research Results	TAs	TNZ	IOs
Subscriptions to Periodicals	%	%	%
- NZ Local Government Magazine	100	100	50
- NZ Engineering	89	100	50
- Transearch	84	100	100
- World Highways	24	75	100
- SHRP In Focus	4	25	100
- ARRB Roads & Transportation	49	100	100
- ASCE Transportation Journal	4	25	0
- ICE Transportation Journal	4	25	0
- Transportation Research Record (USA)	2	25	50
Regular Conference Attendance	76	100	100
Internet Resources	24	100	100

SHRP - State Highway Research program ARRB - Australian Road Research Board
ASCE - American Society of Civil Engineers ICE - Institute of Civil Engineers

Another aspect of this section of the questionnaire was to gauge the perceived effectiveness of the current state-funded research with respect to providing an improved end-product to the road user. The perception was rated on a scale of 1 to 5, where 1 corresponds to an ineffective rating and 5 corresponds to a highly effective rating. Figure 3.1 shows the results of this inquiry in histogram form for all responses. The mean rating over all responses was 3.5.

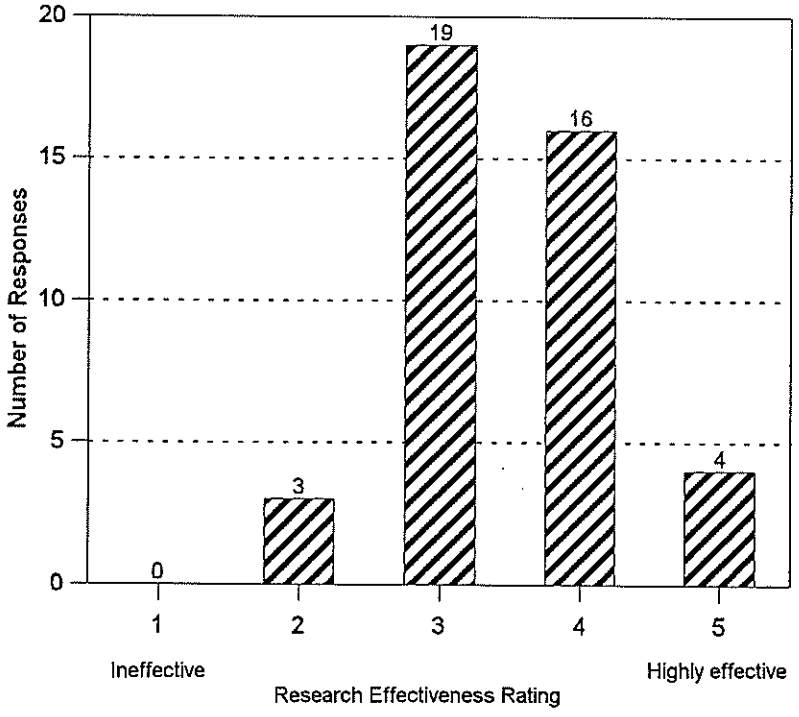

Figure 3.1 Ratings (1- ineffective to 5 - highly effective) for research effectiveness.

Comments provided by respondents regarding potential ways of improving the state-funded research programmes are summarised as follows:

- Ensure that projects are practical and implementation gets the results to the right people. Conduct workshops and courses to communicate the findings to the roading community.
- Most research is carried out on new construction or sealed pavements. More work should be done on unsealed and rural roads as these make up the large proportion of low volume roads in New Zealand.
- Research should be driven by the potential end-users to ensure that projects remain focused and their implementation is effective. Regular communication between the researcher and the (end-user) project manager is essential.

Respondents were asked what specific problems they encounter regularly in their work. Table 3.4 summarises the topics that future research should focus on, as identified by the respondents of the questionnaire.

Table 3.4 Summary of potential research topics, as identified by the questionnaire respondents.

Category	Research Focus
Pavement Deterioration	Examine use of HDM 3 and 4. Investigate damaging effect of overweight loads. Study the expected life of urban streets. Investigate the link between RAMM data and deterioration models. Investigate linking of deterioration models and financial plans. Develop pavement depreciation techniques for accounting purposes. Develop enhanced asset management tools. Develop analyses of true transportation costs. Investigate effects of various maintenance regimes on pavement remaining life. Determine optimum maintenance allocations for different road classes.
Pavement Condition	Investigate roughness measurement. Develop alternative methods of pavement condition monitoring. Investigate acceptable levels of roughness for urban roads. Investigate skid resistance measurement - correlations between methods.
Pavement Design	Develop alternative design procedures. Investigate use of deflection data for rehabilitation design. Investigate applicability of 50-year design life for flexible pavements. Investigate use of very thin pavements for low volume roads. Investigate effect of dynamic loading, suspension types and tyre pressures. Determine performance criteria for lightly cemented aggregates. Develop a design procedure for geogrid-reinforced pavements. Determine appropriate terminal serviceability limits for different pavement classes. Investigate influence of stresses and strains within pavement layers on pavement response and performance.

Table 3.4 (continued)

Category	Research Focus
Unsealed Pavements	Investigate optimal maintenance levels. Determine properties of suitable binding materials. Investigate aggregate modification. Investigate roughness measurement and monitoring. Investigate dust suppression. Develop pavement deterioration models. Develop relationships between pavement performance and parameters such as metalling, grading, climate and traffic. Investigate level-of-service indicators and requirements. Examine effects of forestry traffic.
Sealing	Develop economic means of seal extension. Examine performance of bitumens from various sources. Investigate performance of calcined bauxite. Investigate chipseal performance with respect to modern traffic loads, axle configurations and manoeuvres.
Asphalt	Investigate performance of bituminous membranes beneath asphalt surface layers. Determine appropriate volumetric characteristics for NZ mixes. Determine relationship between pavement condition after construction and future performance. Study the determination of air voids in thin asphalt layers.
Construction	Develop acceptance criteria for compacted basecourse layers. Improve quality control procedures. Develop performance-based specifications for maintenance.
Materials and Products	Investigate use of alternative local aggregates. Determine in situ tests required during construction. Develop a statistical approach to compliance testing. Develop simple methods of characterising pavement materials. Investigate how environmental effects influence material performance. Examine performance of geofabrics and geogrids. Develop subgrade testing methods. Develop standardised national acceptance of new products.
Environment	Study environmental impact assessments for roading projects. Investigate minimising of stormwater run-off pollution. Perform air pollution studies, particularly the effect of heavy vehicles.
Policy	Consider effects of proposed roading reforms. Foster improved co-ordination between state and local government roading authorities.
Road Markings	Develop methods of determining marker condition. Investigate durability of pavement marking materials. Investigate durability of PVC edge marker posts.

HDM Highways Design and Maintenance Standards study (Paterson, W.D.O. 1987. *Road deterioration and maintenance effects models for planning and management.* A World Bank Publication.)

RAMM Road Assessment and Maintenance Management system

3.3 Pavement Design Issues

Transit New Zealand adopted the AUSTROADS procedures for the design of state highways in 1995. The first question of this section was targeted at Territorial Authorities and it inquired into their use (or requirement to use) the AUSTROADS pavement design procedures. The results indicated that 56% of the responding Territorial Authorities either use or require the use of the AUSTROADS pavement design procedures on projects for which they are responsible.

The Territorial Authorities that did not use the AUSTROADS pavement design procedures generally used the method previously condoned by Transit New Zealand, i.e. the design charts contained in Transit New Zealand (1989). This was mainly because of familiarity with the procedure, adequate past performance, and reduced onus for materials characterisation. A small number of respondents indicated that their preferred design method is a "rule of thumb" approach based on local experience.

All participants were asked to indicate their perception of the strengths and weaknesses of the AUSTROADS pavement design procedures. The responses are presented in Table 3.5.

Table 3.5 Strengths and weaknesses of the AUSTROADS pavement design procedures, as perceived by respondents.

Strengths	Weaknesses
Consistency between NZ and Australia allows for effective sharing of information.	Elastic parameters used in design are not well understood and onerous to quantify.
Manual is comprehensive but still easy to use.	Geared towards Australian conditions.
Design is based on a rational mechanistic approach.	Lack of information on stabilised pavements.
Allows alternative materials to be considered.	Lack of NZ performance history.
Useful supplement on Light Traffic pavements.	Expensive software and manuals.
Allows flexibility with respect to loadings, materials, number of layers and performance criteria.	Lengthy and complex compared with previous design procedures.
Promotes rational thought on influences of loadings, materials and environmental factors.	Confusion over the requirement for anisotropic material parameters.
	Emphasis placed on asphalt pavements.
	Designer must have accurate loading and materials data.
	Uses elastic characterisation and not plastic characterisation.
	Sometimes results in over-design for rehabilitation projects.
	Does not allow for subgrade failure caused by construction traffic in areas of high water table.
	Does not allow for a "shift factor" in asphalt performance characterisation.

An important aspect of pavement design is accurate characterisation of the loadings expected throughout the life of the pavement. The participating organisations were asked if they maintain axle count and loading data for their roading network. The results showed that 63% of the responding Territorial Authorities maintain such data. Transit New Zealand has staff dedicated to maintaining axle count and loading data for the state highway network.

The participating organisations were also asked about the specific pavement loading issues that they were confronted with. The results of the Territorial Authority and Transit New Zealand respondents are summarised in Table 3.6.

Table 3.6 Summary of various traffic loading issues identified by respondents.

Loading Issue	Proportion (%) of Organisations Reporting Loading Issues	
	Territorial Authorities	Transit New Zealand
Increasing commercial vehicles	65	100
Increasing axle loads	61	25
Overloading	52	25
Seasonal loading	48	75
Logging trucks	67	100
Port trucks	20	100

3.4 Pavement Performance

An important aspect of the questionnaire was to obtain an indication of whether or not New Zealand pavements are achieving their intended design life and, if not, to explore the reasons for premature failure.

The questionnaire results show that 100% of the Transit New Zealand respondents and 72% of the Territorial Authority respondents indicate that their pavements generally achieve their design lives. For the premature failures that do occur, the contributing factors and predominant modes of failure are summarised in Tables 3.7 and 3.8 respectively.

Table 3.7 Summary of factors contributing to premature pavement failures identified by respondents.

Contributing Factor	Proportion (%) of Organisations Reporting Contributing Factors	
	Territorial Authorities	Transit New Zealand
Increased volume of heavy vehicles	15	0
Increased axle loads	17	0
Poor construction quality	17	0
Poor materials quality	15	0
Seasonal heavy traffic	9	0
Logging traffic	13	0
Environmental factors	15	0
Inappropriate design	13	0

(0 - no response)

Table 3.8 Summary of predominant modes of pavement failure identified by respondents.

Mode of Failure	Proportion (%) of Organisations Reporting Predominant Modes of Failure	
	Territorial Authorities	Transit New Zealand
Rutting	41	25
Cracking	50	50
Shearing	28	50
Pot-holing	33	25
Corrugation	22	0
Edge defects	33	0

Participating organisations were asked to gauge the typical road users' perception of the quality of the roading network using a rating system of 1 to 5, where 1 is a *declining* rating, 3 is a *static* rating and 5 is an *improving* rating. Figure 3.2 shows a histogram summarising the results.

Table 3.9 summarises the factors contributing to the declining / static / improving status of the quality of the roading network as reported by the respondents.

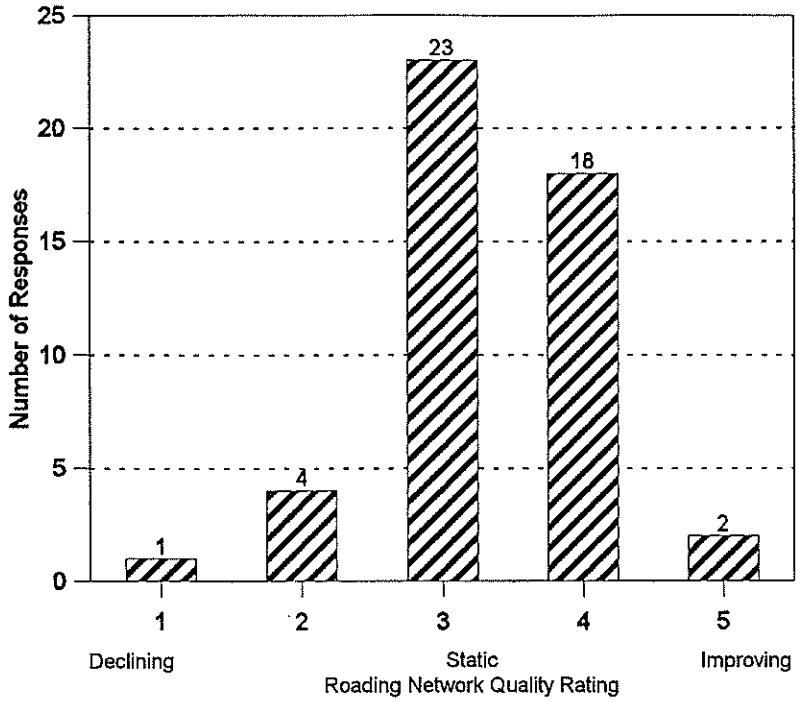

Figure 3.2 Distribution of ratings of roading network quality. (1 - declining to 5 - improving)

Table 3.9 Summary of factors contributing to the perceived quality of the roading network.

Quality Status	Contributing Factors
Declining	Backlog of projects due to funding shortfalls. Increased axle loads. Increased heavy traffic volumes. Poor subgrade soil conditions. Benefit / cost outcomes reducing number of viable projects. Increaased user expectations. Rugged topography makes improvements difficult.
Static	Limited funding available. Additional expenditure but only keeping up with increasing demands.
Improving	Performance-based maintenance contracts. Improved allocation of resources. Improved pavement management techniques. Improved safety standards. Improved pre-seal preparation. Additional seal extensions and shape correction works. Higher construction and maintenance standards. Improved materials. Benefit / cost outcomes increasing number of viable projects.

3.5 Pavement Construction, Rehabilitation and Maintenance

The Territorial Authorities and Transit New Zealand participants were questioned on the status of their maintenance programmes. The results showed that 50% of the Transit New Zealand and 76% of the Territorial Authority respondents considered their roading network maintenance costs were acceptable.

The respondents who considered their maintenance costs to be too high identified the following to be contributing factors:

- Maintenance costs increasing because of general deterioration of network quality.
- Low traffic volumes make it difficult to achieve viable benefit / cost ratios.
- High cost of acquiring and transporting quality construction materials.
- Rehabilitated areas have decreased durability.
- Unfavourable subgrade and/or drainage conditions.
- Network includes a large number of rural roads with little or no structural integrity.
- Inappropriate design or construction processes.

One of the most important roading network maintenance tasks is the provision of a high quality skid-resistant pavement surface. Table 3.10 shows the mean percentages of surfacing types (with respect to area of sealed pavement) used by the responding Territorial Authorities. The table also shows the mean expected life for each surfacing type.

Table 3.10 Mean percentages of surfacing types and expected life values for sealed pavements, reported by responding Territorial Authorities.

Surfacing Type	Mean Proportion (%) of Sealed Network	Mean Expected Surfacing Life (Years)
Chipseal	93	12.9
Plain asphalt	4	16.2
Porous asphalt	1	10.5
Slurry asphalt	1	8.4
Concrete	<<1	38.3

Note that the proportions of surfacing types described in Table 3.10 are reported with respect to the areas of sealed pavement. Most of the Territorial Authorities have a high proportion of unsealed roads in their network, and Figure 3.3 shows a histogram of percentage of unsealed roads reported by the territorial Authorities.

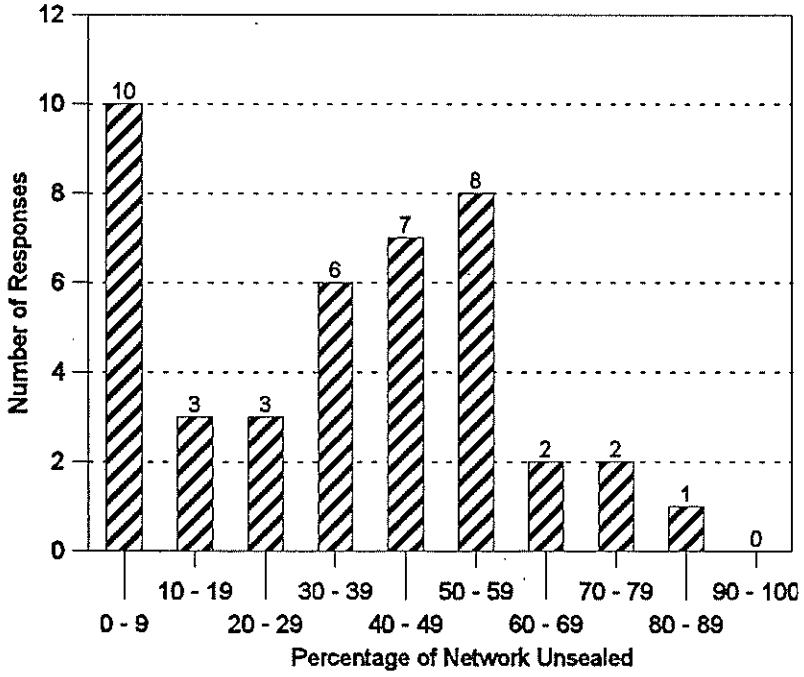

Figure 3.3 Percentages of unsealed roads maintained by Territorial Authorities.

Table 3.11 Accounts of various successes and failures using marginal aggregates.

Successes	Failures
Pavement rehabilitation using cement, KOBM, or lime-stabilised marginal aggregates.	Stabilised marginal aggregates did not achieve performance characteristics predicted by lab tests.
Lime / cement-stabilised marginal aggregates blended with high quality aggregates and used on unsealed roads.	Incorrect grading of marginal aggregates causes poor compaction and results in cracking of surface seal.
Marginal aggregates used to make up metal depths on steep unsealed roads - must have good drainage.	Weathered greywacke failed in a seal pavement situation.
Crushed limestone used as running course on unsealed roads.	Use of silty material to achieve smooth surface prior to sealing has resulted in premature failures.
Pumice and rhyolite materials used on low volume roads as long as drainage is adequate.	Poor performance achieved when marginal aggregate used for patching in winter months.
Shellrock used with good success.	
Weathered greywacke performs well on unsealed roads.	
Marginal aggregates successful but require increased metal depth or stabilisation.	
Marginal aggregates successful if not over-compacted.	

The use of so-called local or marginal aggregates in construction and rehabilitation is an issue that has received a large amount of attention in recent times. This is because premium aggregate resources have been reducing, and correspondingly the cost of processing and transporting the material has been increasing. An alternative approach is to utilise marginal materials, with or without some form of improvement technique. The survey participants were asked if their organisations use marginal aggregates and with what degree of success (or failure).

The results show that 75% of the Transit New Zealand respondents and 46% of the Territorial Authority respondents have used marginal aggregates in their construction and / or rehabilitation projects. Table 3.11 lists various accounts of successes and failures using marginal aggregates.

One of the objectives of the project was to solicit information regarding innovative or unique pavement engineering practices that may be of interest to the roading fraternity in general. The following responses were obtained:

- Use of recycled asphalt on site.
- Use of geogrids and geofabrics for pavement stabilisation.
- Use of lime/cement stabilisation.
- Long-term performance monitoring of urban road pavements.
- Use of calcined bauxite to provide skid resistance in an accident black-spot location.
- Use of limestone for strengthening unsealed roads.
- Use of a limestone / "blue metal" blend for pot-hole repair.
- Implementation of maintenance specifications with "zero response times".
- Use of aggregate comprising crushed concrete and recycled road surfacing and basecourse materials.
- Use of steel fibre-reinforced concrete in a roundabout situation.
- Achieving a quality surface using a polymer-modified bitumen and Grade 2/3 chip, capped with a Type 2 or 3 slurry seal.

4. ANALYSIS OF RESULTS

The following Sections 4.1 to 4.5 present a discussion of the information contained on the completed questionnaires. The discussion is based on the author's interpretation of the responses and does not necessarily reflect the author's own views on the various topics.

4.1 Background Information

The background information supplied by the respondents showed that the main functions performed by Territorial Authorities comprise pavement management, network planning, contract management and pavement design. Most of the other pavement engineering tasks are carried out on behalf of Territorial Authorities by external contractors. The results also showed that the main functions performed by Transit New Zealand offices comprise pavement management, network planning, contract management and safety audits. The limited number of responses from Industry Organisations made their background information data inconclusive.

4.2 Pavement Engineering Research

Most of the respondents recognise the need for further research in the pavement engineering field, although very few of the Territorial Authorities perform their own research or have an involvement in state-funded research. A higher number of Territorial Authorities utilise the results of state-funded research, and this is virtually exclusively from the Transfund / Transit NewZealand research programmes. Territorial Authorities appear to make no use at all of FSRT- or university-funded research. It is important that the latter programmes improve their awareness and/or implementation strategies to redress this situation.

The respondents indicated that the effectiveness of state-funded research programmes is reasonably good. This approval was qualified by comments that the research programmes must maintain a focus on relevant and practical issues, and they must be driven by the end-user to ensure timely and thorough implementation.

A number of potential research topics have been identified in the responses to the questionnaire. These are presented in Table 3.4, and they cover a variety of aspects of pavement engineering. However there was a general feeling that too much research effort is placed on the urban road environment instead of focusing on the more widespread challenge of maintaining relatively low volume rural roads. These include issues such as maintenance strategies for unsealed roads, inexpensive seal extension practices, dust suppression, etc.

Dissemination of research information is generally achieved using technical periodicals, conference proceedings, workshops and, in recent times, internet

resources. The Transit New Zealand and Industry Organisation respondents appear to utilise each of these resources thoroughly while Territorial Authorities seem to rate somewhat lower in the use of technical periodicals and particularly internet resources. A greater acceptance of these resources should be encouraged to maximise the many benefits that they can provide.

4.3 Pavement Design Issues

An interesting aspect of the survey was the relatively low rate of acceptance (56%) of the AUSTROADS pavement design procedures by Territorial Authorities, given that Transit New Zealand adopted the procedures as policy in 1995. While many Territorial Authorities recognised a number of benefits achieved by using the AUSTROADS procedures, some objected to its use on the grounds that it is overly complex or lacks a long-term performance history in New Zealand. While these objections may be valid, a number of objections also appear to be misconceived or unwarranted.

Of the Territorial Authorities that do not require use of the AUSTROADS pavement design procedures, most have maintained the design procedures of the previous Transit New Zealand *State Highway Pavement Design and Rehabilitation Manual* (1989). Others use a "rule of thumb" approach based on extensive local knowledge.

One of the main reasons for Transit New Zealand adopting the AUSTROADS pavement design procedures was to take advantage of a consistency of approach between the New Zealand and Australian roading communities. This allows information and documentation to be shared between the two countries resulting in technological and ultimately economic benefits. With Transit New Zealand having implemented this move, it would appear to be beneficial for New Zealand's Territorial Authorities to follow a similar policy of consistency. This would not necessarily nullify the large amount of local knowledge accumulated by Territorial Authorities but it would promote the use of this information within a sound and consistent framework of procedures. Therefore, the consistent acceptance of the AUSTROADS pavement design procedures throughout New Zealand should be encouraged.

An important component of any pavement design process is the evaluation of loadings, both in terms of magnitude and volume. Transit New Zealand maintain traffic loading data for the state highway network while 63% of the responding Territorial Authorities perform traffic monitoring on their own networks. The latter figure is somewhat low considering that the traffic loading parameter is fundamental to effective pavement management.

Territorial Authorities identified a number of aspects of pavement loading that are relevant to their respective road networks. Of these, logging trucks, increasing volumes of heavy commercial vehicles, and increasing axle loads were of particular concern. Overloading and seasonal loading also received a number of responses.

4.4 Pavement Performance

An interesting outcome of the survey was that 100% of the Transit New Zealand respondents and 72% of the Territorial Authority respondents indicated that their pavements generally achieve their expected design life. Where failures do occur they most commonly manifest as surface cracks.

Other failure modes in decreasing order of frequency were rutting, pot-holing, edge defects, shearing, and finally corrugations. Factors that generally contribute to premature failures included loading, construction quality, materials quality, environmental conditions, and design. Each of these factors received approximately equal ranking.

Respondents indicated that, in general, the overall quality of their roading network in terms of the product the end-user receives is either static or tending to increase. While some Territorial Authorities indicated a decline in network quality, these responses were relatively few in number. Where declines in quality were identified, contributing factors included funding shortfalls, difficult terrain and/or subgrade conditions, and increasing heavy vehicle loads and volumes. These factors were coupled with increasing user expectations.

Factors contributing to increasing network quality were mainly related to improved practices, e.g. the use of performance-based specifications, improved pavement management techniques, improved safety standards, and improved construction standards. It is noted that project evaluation using benefit/cost criteria were cited as contributing to both declining and improving quality.

4.5 Pavement Construction, Rehabilitation and Maintenance

Most of the respondents considered their network maintenance costs to be acceptable. A large proportion of the maintenance expenditure is related to maintaining a watertight and skid-resistant surface on sealed roads. By far the most common surfacing type is chipsealing which has a mean life expectancy of almost 13 years. Various asphalt surfacings, as well as concrete, were acknowledged but they are used in very small proportions compared with chipseals.

While there is a large area of sealed pavement in New Zealand, the survey showed that more than 50% of the responding Territorial Authorities have 40% or more of their network unsealed. The management and maintenance of these roads represent a large proportion of the work that many Territorial Authorities carry out. Therefore, it is important that the New Zealand roading research effort reflects this situation.

The use of so-called local or marginal aggregates in pavement construction and rehabilitation is a topic that raises a variety of opinions. Using these materials has been common for many Territorial Authorities because of a lack of high quality aggregates in their regions.

When quizzed on this topic, 75% of the Transit New Zealand respondents and 46% of the Territorial Authority respondents indicated that they had used marginal aggregates in their pavement projects. Although a number of successes were cited, these are however mainly accompanied by important qualifications such as the need to improve the properties of the marginal material using lime/cement/KOBM stabilisation and/or blending with superior materials. The provision of adequate drainage was also identified as being very important.

Appropriate use of marginal materials appears to be a fertile ground for future research as dwindling supplies of premium aggregate will result in higher production and transportation costs. Similarly, the use of waste materials in pavement construction, such as recycled asphalt and crushed bricks and concrete, should receive research attention in the near future.

The unique or innovative procedures solicited from the survey respondents also provide topics for future research. The main emphasis of such research should be to determine if similar techniques can be used in other parts of New Zealand with comparable success.

5. CONCLUSIONS

This report presents the results of a survey of New Zealand's Territorial Authorities, Transit New Zealand, and selected Industry Organisations on pavement engineering issues. The survey was carried out using a questionnaire which was designed to determine which areas of pavement engineering require further research in the near future. The questionnaire also asked related questions regarding pavement design, performance and construction issues. Finally, it sought to solicit information on unique or innovative pavement engineering practices that may be of interest to the New Zealand roading fraternity in general.

The main conclusions that can be drawn from the project are as follows:

- The perception of the majority of the respondents regarding the status of the pavement engineering situation in New Zealand is reasonably positive. Most respondents indicated that the quality of their roading networks is increasing, pavements generally achieve their intended design lives, and maintenance costs are acceptable. Clearly, there are exceptions to this perspective, but the feedback received in this project appears to be more positive than negative.

- When premature failures do occur, the main contributing factors have been identified in general to be increased loadings, construction problems, materials problems, adverse environmental conditions, and inadequate design. Each of these factors was assigned approximately equal weighting by the respondents. The main modes of pavement failure are generally (in decreasing order of frequency): cracking, rutting, pot-holing, edge defects, shearing, and formation of corrugations.

- Having concluded that the quality of New Zealand's roading networks is generally increasing, there is recognition that further research is nevertheless required. A number of potential research topics have been presented.

- The involvement of Territorial Authorities in pavement engineering research that is funded by themselves or by the state is reasonably limited. This is to the detriment of the roading fraternity as a whole because Territorial Authorities are major users of pavement engineering technology, and they would benefit greatly from the implementation of research findings.

- While the acceptance of state-funded research programmes appears to be quite high, most respondents qualified their response regarding the relevance and timely implementation of the research findings. For example, the survey information suggests that not enough effort is expended on researching the performance of low volume rural roads when these roads represent a significant proportion of New Zealand's roading network.

- Territorial Authorities receive virtually no benefit from state-funded research programmes except those promoted by Transfund (and formerly Transit) New Zealand. University- and FSRT-funded research programmes must improve their awareness and/or implementation strategies to ensure that they are utilised to the best advantage.

- It is vital that all research programmes are directed by the end-user. This will ensure that a programme remains focussed on the topic at hand and promotes a clear and timely implementation of the research findings into practice.

- Irrespective of Transit New Zealand's adoption in 1995 of the AUSTROADS pavement design procedures, a number of Territorial Authorities do not use, or do not require the use of, the AUSTROADS procedures. A consistency of approach would be advantageous and this should be promoted actively.

- The use of so-called marginal aggregates has received moderate support by Territorial Authorities. Most of the respondents that do use marginal aggregates caution that the materials generally require improvement by some means, e.g. lime/cement/KOBM stabilisation and / or blending with superior materials. The importance of drainage is also stressed. The appropriate use of marginal materials is a topic that deserves further research in the near future as the resources of premium aggregates become depleted.

- A small number of unique or innovative practices have been obtained from respondents and these are listed in the report. A relevant research objective would be to investigate some of these practices to ensure that they can be used successfully throughout New Zealand.

6. REFERENCES

AUSTROADS. 1992. *Pavement Design: A Guide to the Structural Design of Road Pavements.* AUSTROADS Publication No. AP 17/92, Sydney, Australia.

Transit New Zealand. 1989. *State Highway Pavement Design and Rehabilitation Manual.* Transit New Zealand, Wellington, New Zealand.

Transit New Zealand. 1998. *Pavement Design: A Guide to the Structural Design of Road Pavements. New Zealand Supplement.* Transit New Zealand, Wellington, New Zealand.

APPENDIX A
ORGANISATIONS INVITED TO PARTICIPATE IN SURVEY

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ORGANISATIONS INVITED TO PARTICIPATE IN SURVEY

Ashburton District Council
Auckland City Council
Auckland Regional Council
Banks Peninsula District Council
Environment Bay of Plenty
Buller District Council
Canterbury Regional Council
Carterton District Council
Central Hawke's Bay District Council
Central Otago District Council
Chatham Islands Council
Christchurch City Council
Clutha District Council
Dunedin City Council
Far North District Council
Franklin District Council
Gisborne District Council
Gore District Council
Grey District Council
Hamilton City Council
Hastings District Council
Hauraki District Council
Hawke's Bay Regional Council
Horowhenua District Council
Hurunui District Council
Hutt City Council
Invercargill City Council
Kaikoura District Council
Kaipara District Council
Kapiti Coast District Council
Kawerau District Council
Mackenzie District Council
Manawatu District Council
Manawatu-Wanganui Regional Council
Manukau City Council
Marlborough District Council
Masterton District Council
Matamata-Piako District Council
Napier City Council
Nelson City Council
New Plymouth District Council
Northland Regional Council
North Shore City Council
Opotiki District Council
Otago Regional Council
Otorohanga District Council
Palmerston North City Council
Papakura District Council
Porirua City Council
Queenstown-Lakes District Council
Rangitikei District Council
Rodney District Council
Rotorua District Council
Ruapehu District Council
Selwyn District Council
Southland District Council
Southland Regional Council
South Taranaki District Council
South Waikato District Council
South Wairarapa District Council
Stratford District Council
Taranaki Regional Council
Tararua District Council
Tasman District Council
Taupo District Council
Tauranga District Council
Thames-Coromandel District Council
Timaru District Council
Upper Hutt City Council
Waikato District Council
Environment Waikato
Waimakariri District Council
Waimate District Council
Waipa District Council
Wairoa District Council
Waitakere City Council
Waitaki District Council
Waitomo District Council
Wanganui District Council
Wellington City Council
Wellington Regional Council
West Coast Regional Council
Western Bay of Plenty District Council
Westland District Council
Whakatane District Council
Whangarei District Council
NZ Bitumen Contractors' Association Inc.
Cement & Concrete Association of New Zealand
NZ Contractors' Federation (Inc.)
Transit New Zealand (Head Office)
Transit New Zealand (Regional Offices)

APPENDIX B
SURVEY QUESTIONNAIRE

SURVEY OF NEW ZEALAND ROADING AUTHORITIES REGARDING PAVEMENT ENGINEERING ISSUES

Questionnaire Form

Bartley Consultants Limited

Project funded by : Transfund New Zealand

October 1998

SURVEY OF PAVEMENT ENGINEERING ISSUES

RESPONDENT'S DETAILS:

I) Organisation: .....

ii) Name: .....

iii) Position: .....

iv) Telephone Number: .....

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1 BACKGROUND INFORMATION

1.1 Which of the following functions are carried out within your organisation or let to external contractors:

Function	Within	External
Pavement management	Yes / No	Yes / No
Network planning / policy	Yes / No	Yes / No
Pavement geometrical design	Yes / No	Yes / No
Pavement structural design	Yes / No	Yes / No
Pavement rehabilitation design	Yes / No	Yes / No
Pavement condition surveys	Yes / No	Yes / No
Transportation studies	Yes / No	Yes / No
Safety audits	Yes / No	Yes / No
Materials testing	Yes / No	Yes / No
Pavement construction	Yes / No	Yes / No
Seal extensions	Yes / No	Yes / No
Pavement maintenance (sealed)	Yes / No	Yes / No
Pavement maintenance (unsealed)	Yes / No	Yes / No
Contract management	Yes / No	Yes / No
Other - Specify below	Yes / No	Yes / No

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2 PAVEMENT ENGINEERING RESEARCH

2.1 State funding for pavement research projects in New Zealand generally originates from three sources, i.e. Transfund NZ (formerly Transit NZ), the Foundation for Science, Research and Technology, and University Scholarships.

If your organisation has been involved in state funded research projects please indicate the source of the funding:

Transfund / Transit NZ	Yes / No
Foundation for Science, Research & Technology	Yes / No
University Scholarships	Yes / No

2.2 If your organisation has utilised the results of state funded research projects undertaken by others please indicate the origins of the research reports:

Transfund / Transit NZ	Yes / No
Foundation for Science, Research & Technology	Yes / No
University Scholarships	Yes / No

2.3 In your view, how effective is state funded pavement research with regard to improving the end-product provided to New Zealand road users?

1	2	3	4	5

Ineffective ***Effective*** ***Highly Effective***

2.4 If you rated the state funded research programmes to be effective or worse, i.e. 3 or less on the above scale, please state how, in your view, the research programmes could be improved. Use further sheets if required.

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2.5 Does your organisation carry out its own research into pavement engineering issues?

Yes / No

2.6 If the answer to question 2.5 is YES, what aspects of pavement engineering have been researched within approximately the last five years? Use further sheets if required.

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2.7 Which of the following publications does your organisation subscribe to. Please enter any other titles that are not specified below.

NZ Local Government Magazine	Yes / No
NZ Engineering	Yes / No
Transearch	Yes / No
World Highways	Yes / No
SHRP In Focus	Yes / No
ARRB Roads and Transportation	Yes / No
ASCE Transportation Journal	Yes / No
ICE Transportation Journal	Yes / No
Transportation Research Record (USA)	Yes / No

2.8 Have any of the pavement engineering staff at your organisation attended conferences or seminars associated with pavement engineering issues within the last two years?

Yes / No

2.9 Does your organisation utilise the internet to obtain information on pavement engineering issues?

Yes / No

2.10 Are there any facets of pavement engineering that you consider require further research and improvement? Please include, but do not confine your considerations to, issues such as design philosophy, pavement deterioration models, materials characterisation, materials and construction specifications, roughness and condition surveys, construction quality control, safety, environmental factors, etc.

Yes / No

2.11 If the answer to question 2.10 is YES, please outline the nature of the problems that you would like to see addressed in order of priority. Use further sheets if required.

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3 PAVEMENT DESIGN ISSUES

3.1 Does your organisation use (or require the use of) the AUSTROADS structural pavement design procedures for new and/or rehabilitated pavement projects?

Yes / No

3.2 If the answer to question 3.1 is YES, please list in order of priority the major strengths and the major weaknesses (in your opinion) of the AUSTROADS structural pavement design procedures. Use further sheets if required.

Strengths.....

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Weaknesses.....

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3.3 If the answer to question 3.1 is NO, which design procedures do you use and why? Use further sheets if required.

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3.4 Does your organisation maintain axle count and loading data for your roading network?

Yes / No

3.5 Which traffic loading issues (if any) are you confronted with on your roading network? Please enter any other issues that are not specified below.

Increasing commercial vehicle numbers	Yes / No
Increasing axle loads	Yes / No
Overloading	Yes / No
Seasonal loading	Yes / No
Logging trucks	Yes / No
Port trucks	Yes / No

4 PAVEMENT PERFORMANCE

4.1 Are your pavements generally achieving their expected structural design lives?

Yes / No

4.2a If the answer to question 4.1 is NO, what factors have contributed to the premature pavement failures? Please enter any other factors that are not specified below.

Increased heavy commercial vehicles	Yes / No
Increase axle loads	Yes / No
Poor construction quality	Yes / No
Poor materials quality	Yes / No
Seasonal heavy traffic	Yes / No
Logging traffic	Yes / No
Environmental factors	Yes / No
Inappropriate design	Yes / No

4.2b What is the predominant mode of failure? Please enter any other modes of failure that are not specified below.

Rutting	Yes / No
Cracking	Yes / No
Shearing	Yes / No
Pot-holing	Yes / No
Corrugation	Yes / No
Edge defects	Yes / No

4.3 Is the overall quality (including roughness, safety and capacity) of your roading network perceived by the typical road user to be:

1	2	3	4	5

Declining ***Static*** ***Improving***

4.4 What are the main reasons for the *Declining / Static / Improving* status of the quality of your roading network? Use further sheets if required.

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5 PAVEMENT CONSTRUCTION, REHABILITATION AND MAINTENANCE

5.1 Are the maintenance costs on your roads acceptable?

Yes / No

5.2 If the answer to question 5.1 is NO, please describe what factors cause the costs to be unacceptable? Are there any issues that could be resolved by future research projects? Use further sheets if required.

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5.3 What percentage (approximately) of the roads in your network are unsealed?

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5.4 Of the roads in your network that are sealed, what is the approximate proportion of each of the following surfacing types and what is the typical life expectancy?

Surfacing Type	**Estimated % of Network**	**Typical Surfacing Life**
Chip seal		
Plain asphalt		
Porous asphalt		
Slurry asphalt		
Concrete		
Other - state:		
Other - state:		
	100%	

5.5 Does your organisation utilise so-called marginal materials in pavement construction and / or maintenance?

Yes / No

5.6 If the answer to question 5.5 is YES, what successes or failures have you experienced using marginal materials. What special techniques (if any) are used to mitigate their deleterious properties? Use further sheets if required.

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5.7 Has your organisation developed unique or innovative practices that you consider other roading practitioners could benefit from using or trialing?

Yes / No

5.8 If the answer to question 5.7 is YES, please outline the nature of the unique practices and the benefits that have been achieved. Use further sheets if required.

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Thank you for your responses. Please return the questionnaire along with any additional sheets to Bartley Consultants Limited in the envelope provided by October 30, 1998.