Risk Based Bridge Asset Management

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SYNOPSIS

Following the High Court decision in May 2001 in *Brodie vs Singleton Shire Council*, common law non feasance protection can no longer be guaranteed. While some States have reinstated non-feasance immunity through statute law, there is a greater reliance on "policy defence" to manage civil liability.

In order to effectively implement a policy defence it is important to document and implement a risk based asset management system encompassing the following features:

- Regular documented inspection programs
- Document allocation of funding for repair and maintenance
- Document competing demands on resources
- Determined intervention levels
- Prioritisation actions and document reasons for prioritisation
- Determination if further proactive inspections are required.

As bridges are complex structures with a multitude of components and structural forms, a comprehensive management system is required. Ideally the system will use computer processes to store and manipulate data to provide outcomes to meet the risk based asset management objectives of a road authority.

This paper provides further details on the philosophy of policy defence and the requirements to ensure bridge management practices can rely on such a defence. In particular the paper outlines contemporary bridge risk management processes and how they are used to deliver an effective bridge management system.

1 INTRODUCTION

1.1 Loss of Non-feasance Immunity

On 31 May 2001, the responsibilities for highway authorities significantly changed. The High Court decision in the *Brodie v Singleton Shire* case reversed the previous Common Law position that highway authorities were not liable for not taking action to remedy a problem with a road or bridge. This was commonly known as non-feasance immunity.

In 1991, Mr Brodie was travelling along a road within the Shire of Singleton. When crossing Forrester's Bridge, the timber structure partially collapsed causing injuries to Mr Brodie and damaging the truck he was driving. The driver and truck owner sued the Council alleging negligence in failing to detect white ants and/or dry rot in the bridge girders. The Council based its defence on the non-feasance rule.

The case then went all the way to the High Court which set aside the decision of the appeal and found for Brodie. The implications of the decision are:

- A highway authority must remedy risks to road users within a reasonable time.

- There is a positive obligation on highway authorities to inspect to identify risks.
- Where a danger could not reasonably be expected to exist, generally there will be no breach of duty.
- The authority is no longer protected if a Contractor creates a risk or danger.
- Providing adequate signage is a reasonable action.
- There is not an obligation to keep the road (or bridge) in a state of perfect repair.

1.2 Review of the Law of Negligence

In light of this decision and a number of other decisions, it was recognised the award of damages for personal injury was becoming unaffordable and unsustainable. In May 2002, the Commonwealth Government in consultation with the States and Territories agreed to jointly appoint an expert panel to examine the law of negligence. One of the terms of reference required the Panel to address the principles applied to negligence to limit the liability of public authorities, such a state road authorities and local government.

The panel was not persuaded that non-feasance immunity should be restored, but recognised that public authorities had to make a policy decision on how much to spend on a variety of services such as road safety, health services, education etc. While such decisions may have adverse consequences for individuals, they are considered justifiable from a wider public interest perspective. As a result, the panel preferred the concept of “policy defence” in which liability cannot be imposed where a public authority’s failure to take precautions to avoid a risk was the result of a reasonable decision about allocation of scarce resources or was based on some other reasonable political or social consideration.

It should be noted the policy defence is available only in cases where a public authority has made a policy decision about the performance of a public function, such as a bridge. The defence is not available where an authority did not consider whether or not to perform a function. It is therefore important for a public authority to have a written policy describing the management strategies and allocation of resources for their bridges.

1.3 State Legislation

Most states in Australia have now passed legislation to make available the concept of policy defence. Some states have re-introduced the concept of non-feasance protection, but it usually only applies if an authority did not have knowledge of a hazard involved in an accident. Where an authority did have knowledge, it would need to rely on “policy defence” principles to demonstrate it had acted reasonably.

Victoria, for example, has rejected the concept of reintroducing non-feasance protection, and proposes road authorities should have the protection of “policy defence”, and that decisions set out in a road management plan should be taken as a “policy decision” for these purposes.

2. BRIDGE MANAGEMENT

It is clear authorities can no longer rely on non-feasance protection and that appropriate risk based asset management processes need to be implemented to effectively manage their bridge assets and provide an effective policy to civil liability claims. A risk based asset management system should document and implement the following:

- Regular inspection programs
- Intervention levels
- Allocation of funding for repair and maintenance
- Prioritised actions and reasons for prioritisation
- The competing demands on resources
- Further proactive inspections

As bridges are complex structures with a multitude of components and structural forms, a comprehensive management system is required. The process for effective risk based bridge management is shown in Figure 1.

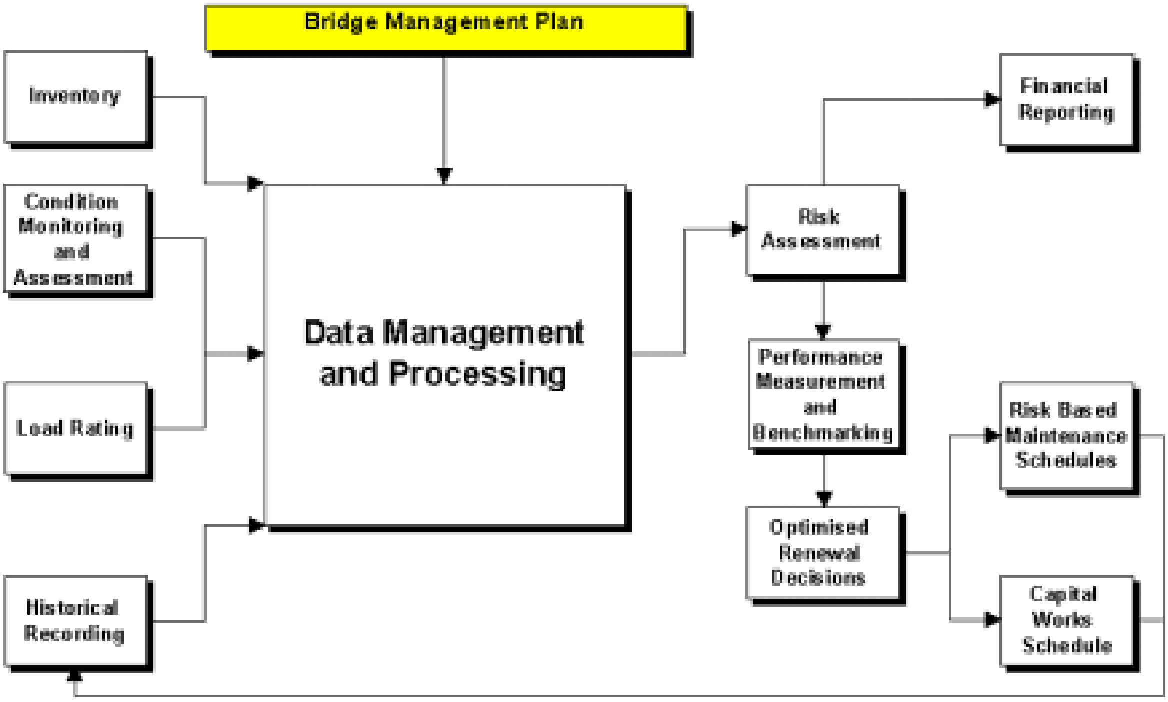


Figure 1: Bridge Asset Management Flowchart

Ideally the system will use computer processes to store and manipulate data to provide outcomes to meet the risk based asset management objectives of the organisation.

2.1 Bridge Management Plan

The Bridge Management Plan is an overriding document outlining bridge management strategies and policies of an authority. It forms the basis of a policy defence in managing civil liability.

The plan should document:

- Bridge management strategies of the authority based on policy and operational objectives and available resources.
- Management responsibility.
- Management practices and standards for:
  - Inspections.
  - Risk management processes.
  - Intervention levels.
  - Scheduling.
  - Bridge replacement.
- An accurate account of:
  - The level of service to the asset.
  - Expenditure.
  - Future issues and needs

2.2 Inventory

It is a key responsibility of a road authority to establish an asset register, which identifies responsibility for maintenance, including statutory services that may be attached to a structure. This information should be retrievable and should also include original design documentation, photographs and historical inspection and maintenance information.

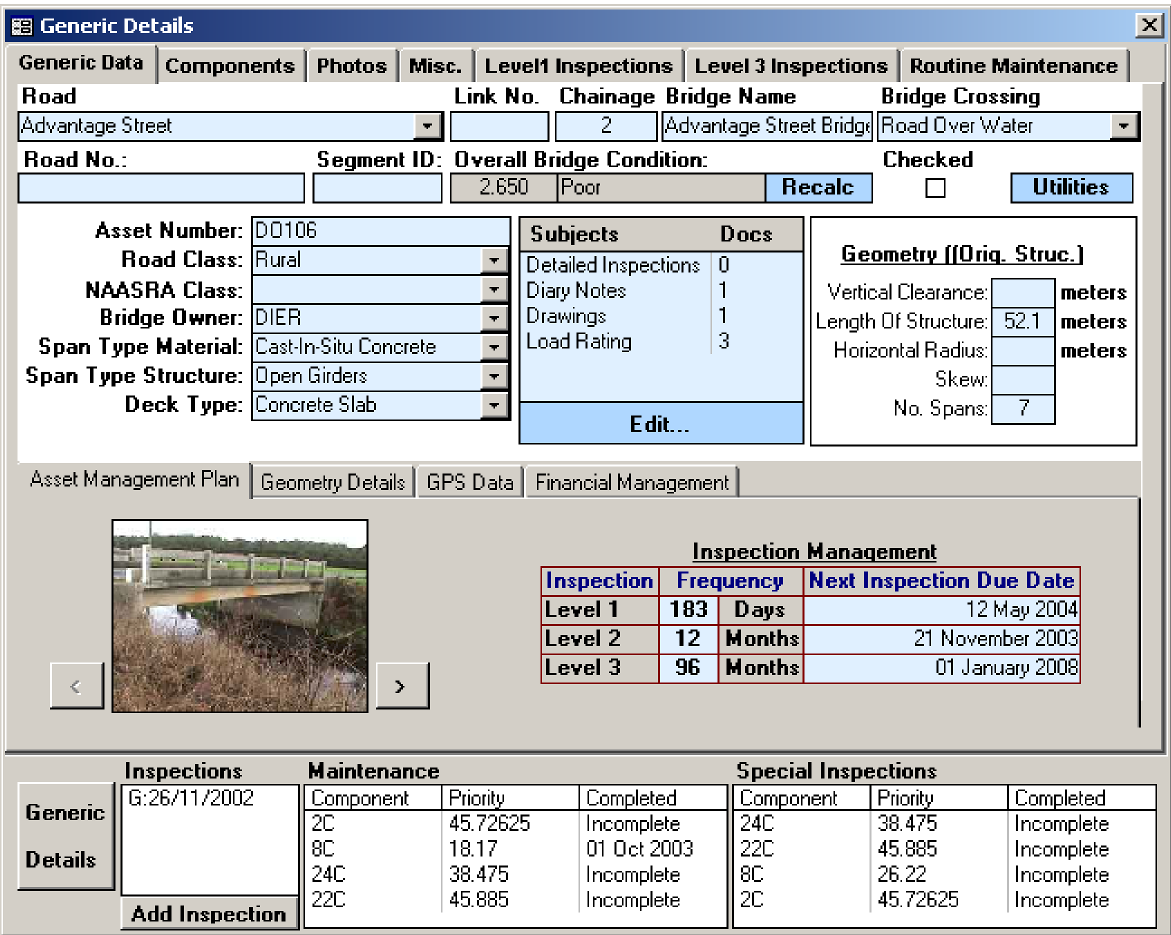


Figure 2: Typical Inventory Information

2.3 Condition Monitoring & Assessment

A road authority must undertake regular inspections to detect deterioration or defects that may require repair or maintenance. A widely accepted hierarchy of bridge inspections includes:

Level 1 – Routine maintenance inspections carried out in conjunction with routine pavement maintenance to check the general serviceability of the structure for road users. The inspections are normally carried out on a 6 monthly basis.

Level 2 – Comprehensive visual inspections carried out by an experienced bridge inspector on an annual or 2 yearly basis, or even longer, depending on the risk profile of the bridge. The inspections involve detecting significant defects in structural members above ground level and rating the condition of each component.

Level 3 – Detailed engineering inspections undertaken when issues requiring further investigation are identified during the Level 2 inspection process, and are carried out by qualified engineers.

2.4 Load Rating

The most important requirement for any road authority is to understand the load capacity of bridges, including the capacity for “heavy loads”. When load rating information is not available a load assessment should be carried out in accordance with the “Guidelines for Bridge Load Capacity Assessment”.

2.5 Risk Assessment

The principal outcome from the High Court decision in *Brodie* was that road authorities must manage risk. Therefore the management of risk should be at the centre of all management processes for bridges, particularly for determining and monitoring intervention levels and prioritising bridge maintenance.

Where authorities have processes in place, most rely on the Level 2 Inspection Reports as the basis for effective risk management. Risk can be defined as the product of the probability of failure and the consequence of failure, ie:

Risk Score = Probability (of failure) x Consequence (of failure)

The analysis for both probability and consequence of failure can be simplified in order to make the overall assessment procedure more practical and easy to interpret. Importantly it can be used within a computer program to automatically generate risk scores.

2.5.1 Component Risk Score

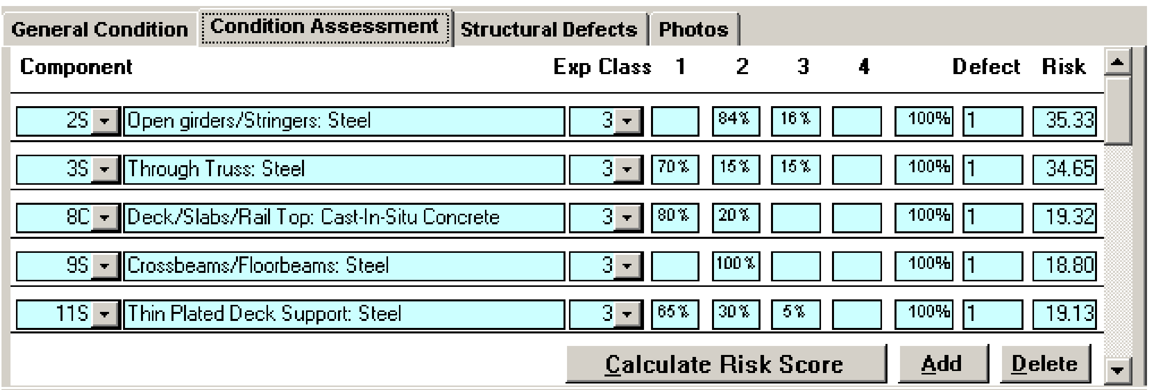
The probability of failure can be expressed as a function of the structural capacity of a component, or the structure as a whole. The following factors are included in the evaluation of the probability of failure of a component:

Condition Factor - Based on Level 2 inspection condition rating for the component.
Load Rating Factor - Reflects the strength to which the bridge, and consequently its components, was initially designed.
Material Factor - Materials have different strength and deterioration profiles
Criticality Factor - Based on the usage and importance of the bridge to the network.

The consequences of failure is an evaluation of the impact of failure. For each component the consequence of failure is assessed under the following factors:

Structural damage - Potential for damage to the structure itself caused by failure of the component
Loss for life - Potential for loss of life, or personal injury, caused by failure of the component
Loss of service - Probability of service interruption if the structural component fails
Economic factor - Reflects the economic importance of the repair and the increasing cost that could incur if component was left unrepaired

A risk score can be automatically generated in a computer program for each component following a Level 2 inspection. Figure 3 shows a typical Level 2 inspection condition assessment for each component, with the risk score calculated in the final column.


General Condition | Condition Assessment | Structural Defects | Photos

Component		Exp Class	1	2	3	4		Defect	Risk
2S	Open girders/Stringers: Steel	3		84%	16%		100%	1	35.33
3S	Through Truss: Steel	3	70%	15%	15%		100%	1	34.65
8C	Deck/Slabs/Rail Top: Cast-In-Situ Concrete	3	80%	20%			100%	1	19.32
9S	Crossbeams/Floorbeams: Steel	3		100%			100%	1	18.80
11S	Thin Plated Deck Support: Steel	3	65%	30%	5%		100%	1	19.13

Calculate Risk Score | Add | Delete

Figure 3: Level 2 Inspection Data and Component Risk Score

2.5.2 Overall Bridge Condition Score

The above risk rating methodology can be extended to calculate an Overall Bridge Condition (OBC) score for every bridge in the network. For each structure a weighted average of the four highest risk scores is calculated to provide the OBC score.

The OBC score can be automatically calculated for each structure within a computer program. The current value can be shown on the inventory form for each bridge, as shown in Figure 2.

2.6 Performance Measurement & Benchmarking

The bridge management plan should identify performance targets and intervention levels for all structures. The OBC scores provide a transparent risk based method of measuring the performance of the bridge network and benchmarking against the designated targets. Typically, target OBC scores are set for the ultimate condition and a serviceability condition where:

Ultimate Condition -	Indicates a significant number of components in a structure have reached a critical condition and that special management actions should be urgently implemented to mitigate and reduce the risk.
Serviceability Condition -	Indicates a number of components on the structure require maintenance work. While the work may not be urgent, the bridge maintenance schedule should include proposals to undertake work to improve the condition of the bridge.

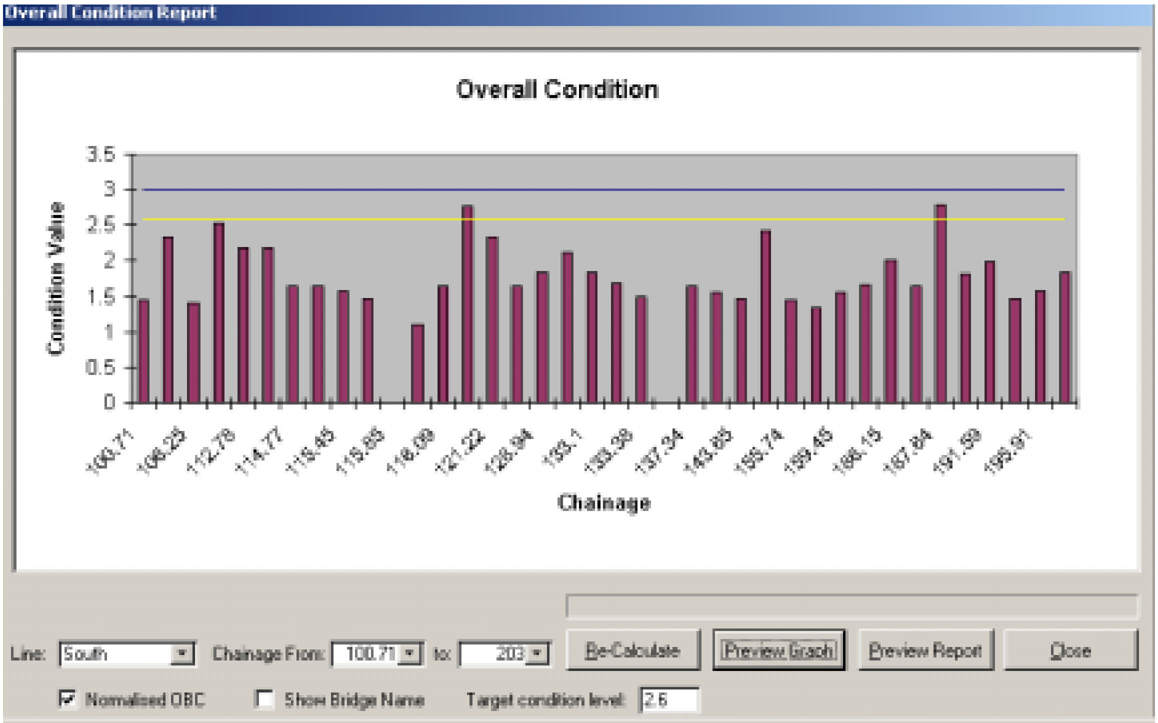


Figure 4: Performance Benchmarking

A computer package can be used to graphically illustrate the performance of the bridges. Figure 4 illustrates the OBC scores for each bridge, with the blue line representing the ultimate condition and the yellow line representing the serviceability target condition.

2.7 Risk Based Maintenance Schedules

It is the duty of a road authority to conduct repair and maintenance works within a reasonable period. As part of the policy defence strategy, the relative importance of the maintenance work should take into account safety issues and the overall budgetary, transport and risk management policies of the authority.

From the risk assessment process, a schedule of highest risk items can be listed to initially identify the highest priority maintenance issues. Following a further engineering review of each identified risk, the bridge asset manager can determine the required remedial work, completion date and anticipated cost to allow a prioritised maintenance schedule to be developed. It may also be necessary to specify a Level 3 engineering inspection to fully determine the cause of the observed defects and the appropriate remedial action.

A computer program can assist in the identification of high risk items, as shown in Figure 5 and then develop a maintenance schedule, as shown in Figure 6.

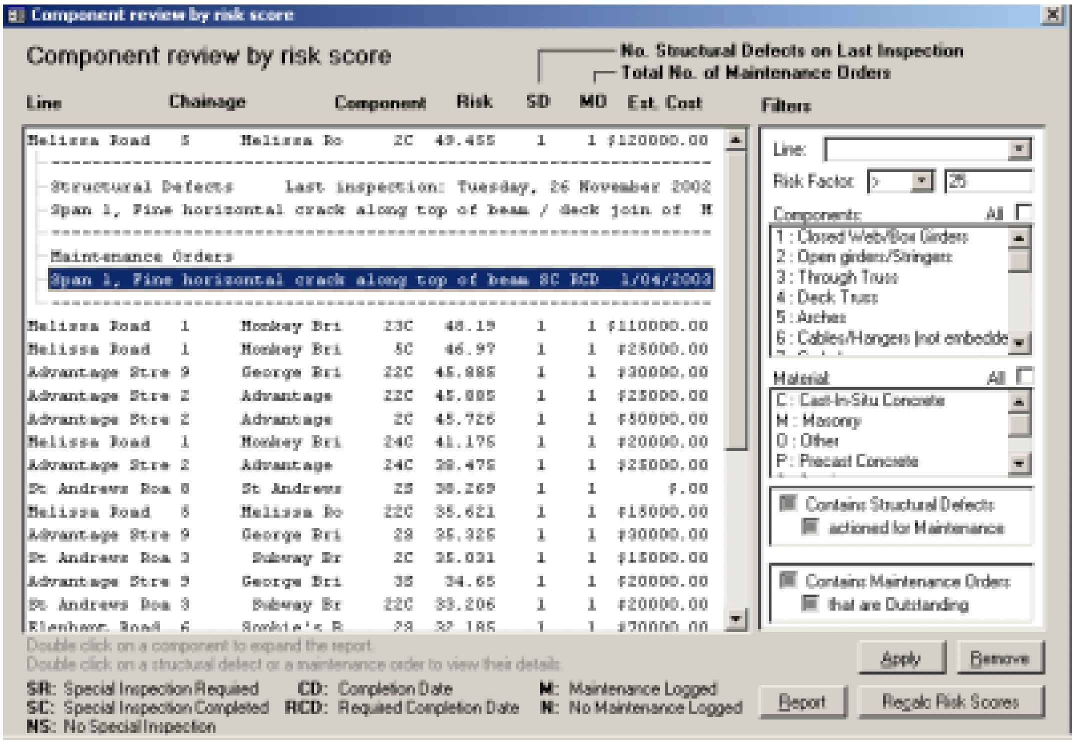


Figure 5: Component Risk Schedule

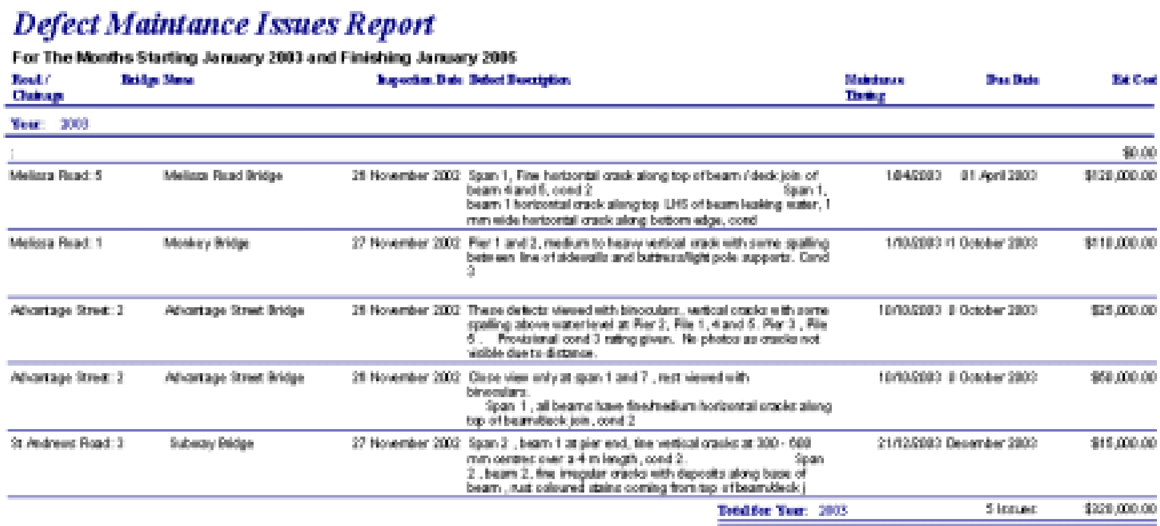


Figure 6: Risk Based Maintenance Schedule

2.8 Optomised Renewal Decisions

For many structures, where the condition of the bridge is poor and significant repairs are required, replacement of the bridge may be a more appropriate strategy. The following process can be carried out to determine the appropriate strategy:

- Using the OBC score, the remaining useful life of the structure can be estimated using an empirical deterioration curve
- The effect of a repair proposal on extending useful life can be modeled by determining the OBC score after the repair. This allows an annual depreciated cost of the repair to be calculated.
- The cost of a new structure is also estimated to allow an annual depreciation cost of a new structure to be calculated.

Bridge: Wilsons#2 (W231.99)

1. Enter estimated actual condition
2. Enter estimated condition after repair (between 1 and 2)
3. Find life span enhancement

Bridge structure material Steel (S), Precast Concrete (P), Timber (T), Other (O)	t
Estimated actual condition	3.1
Estimated virtual age	19 Years
Estimated remaining life before condition 4 is attained	6.3 Years
Estimated condition after repair	2.2
Estimated virtual life at end of repair	14
Life span after repair	33
Life span enhancement	7.7 Years
Repair Cost	15500
Depreciated repair cost/year	2021.739
Replacement cost	105000
Expected life span of new structure	70 Years
Depreciated replacement cost/year	1500

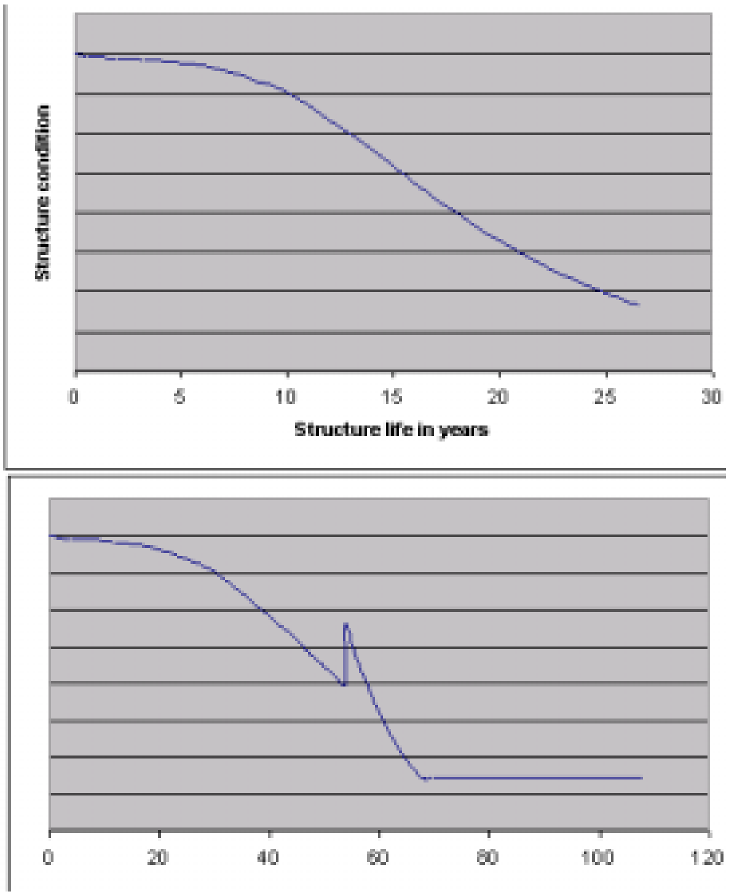


Figure 7: Optomised Renewal Charts

Figure 7 illustrates the evaluation process for a deteriorated timber structure, where the annual depreciation cost of the repair is greater than the replacement option, and hence the economic analysis recommends replacement.

2.9 Capital Works Schedules

A schedule of bridge replacements with associated costs should be developed to predict a future capital works expenditure profile. This allows a road authority to identify the peaks and troughs in potential capital works expenditure and make forward provision for such expenditure.

2.10 Financial Reporting

Understanding the value of assets and the depreciation values are important as part of the statutory reporting requirements. A bridge management system should be able determine bridge replacement estimates, calculate written-down values and depreciation costs in a clear format.

2.11 Historical Recording

Following the completion of maintenance work, it is the duty of a road authority to record the details of the work carried out to provide a historical record. Following the repair, the condition of the component will be improved, which will improve the risk score of the affected component and the structure. By recording the improved condition in the computer program, there will be coresponding improvements in the performance benchmarking histogram in Figure 4 and the component risk schedule in Figure 5.

3.0 DATA MANAGEMENT

Managing all of the data associated with bridges is a complex task ideally suited to a computerised system. While a simple database can be used to store inventory and inspection data, a system that delivers effective bridge management should include the following:

- Risk management processes across the whole network to identify key risks.
- Provide a method for benchmarking the performance of all bridges against prescribed objectives.
- Allow risk-based maintenance and detailed inspections schedules to be developed.
- Allow future capital works expenditure profiles to be identified.
- Undertake asset valuations in accordance with statutory reporting requirements.
- Record maintenance work that has been carried out and document the changing risk profile.

There is also an increasing requirement to link to other systems, such as road asset management systems, GIS and financial systems.

With evolving technology, many road authorities are looking to collect condition data electronically in the field with handheld computers, which synchronise directly into the master database. Figure 8 illustrates a typical handheld device used to collect Level 2 inspection data.

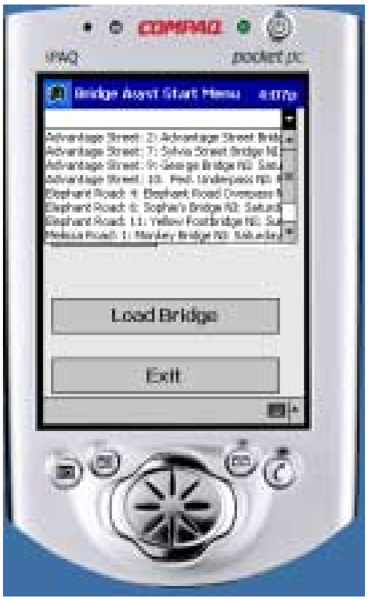


Figure 8: Inspection Datalogger

Figure 9: Level 2 Inspection in Progress

4 SUMMARY AND RECOMMENDATIONS

Following the *Brodie* decision of the High Court, road authorities can no longer rely on non-feasance immunity as a reliable defence. Instead, road authorities must develop a policy defence where liability cannot be imposed where failure to avoid risk was the result of a reasonable decision about allocation of scarce resources.

With respect to bridges, a bridge management plan prepared by a road authority should be taken as a "policy decision" for the purposes of establishing a policy defence to manage civil liability. The bridge management plan should describe the standards and procedures for the implementation of a risk based asset management system, including:

- Regular inspection programs
- Intervention levels
- Allocation of funding for repair and maintenance
- Prioritised actions and reasons for prioritisation
- The competing demands on resources
- Further proactive inspections

Ideally the system should use computer processes to store and manipulate data to provide outcomes to meet the risk based asset management objectives of the road authority, particularly with the increasing demand that bridge management systems are linked to other asset systems within a road authority and that inspection data is collected electronically in the field.

5. REFERENCES & NOTES

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