An Easy to Implement Sustainability Index for Flexible Pavements

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Abstract: This paper proposes a simple low cost SIR (sustainability index for roads) that can be easily implemented by any local government that has a flexible pavement road network. The SIR includes the three pillars of sustainability, economic, social and environmental. The economic pillar is developed from a new perspective of pavement deterioration from the Snowy Mountains Engineering Corporation’s Pavement Management System. The new perspective is easily seen when the deterioration is plotted in three dimensions. This new exponential curve provides an equation for the return on investment in a road network, in terms of a future pavement condition index versus the annual rehabilitation budget. The environmental pillar will be developed by determining which road rehabilitation treatments cause the most environmental damage and recreating the new curve with these treatments being incrementally removed. The resulting curves will provide the annual cost of minimizing environmental damage and the loss of pavement condition index for minimizing environmental damage. The social pillar is, consultation with the community on what pavement condition index they are willing to fund, that is, balancing annual cost, environmental damage and desired pavement condition. This more efficient reporting conforms with the USA Government Accounting Standards Board requirements but not necessarily with the International Financial Reporting Standards. This new SIR reduces the current financial reporting requirement for local governments in Queensland, Australia and can greatly improve comparability of financial reporting, where local governments calibrate the pavement deterioration factors in their Pavement Management Systems and use the newly developed regional rulebase.

Key words: Sustainability, index, roads, financial, comparability.

1. Introduction

The objective of this paper is to provide an opportunity for an easy to implement SIR (sustainability index for roads). The scope of the paper is limited to flexible sealed pavements. The paper covers studies of road networks under the control of a local government in South East Queensland, Australia. The software used for these studies was the SMEC’s (Snowy Mountains Engineering Corporation) PMS (Pavement Management System). This PMS employs the World Bank’s Highway Design and Maintenance Standards Model (HDM-III) deterioration models. Both local governments studied as part of this paper participated in a “Long Term Pavement Performance” (LTPP) study. One outcome of the LTPP study was that the deterioration factors in the HDM-III models have been calibrated to local conditions.

Sustainability can include many components and for this paper, three headings are used, namely: (1) financial; (2) social; and (3) environmental.

The reasoning behind this approach is that, well maintained road networks are essential infrastructure in a modern economy and, as engineers, we must seek to understand the rate of deterioration of our road network so that we can design the future work plans required to preserve them. One limitation of our technical stewardship is that while we may calculate future budgets for the best engineering works programs, it is the community that must be willing to fund (WTF) these programs. Another limitation incumbent upon us as engineers is to provide our
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contribution, to minimising environmental harm due as a consequence of road rehabilitation treatments. The data presented in this paper is based on actual road networks totalling 3,000 km.

2. Literature Review

In Australia, the Department of Infrastructure and Regional Development reported that $26.3 billion was spent on roads in 2013/14 [1]. The Non-Current Asset Accounting Guidelines for the Queensland Public Sector provides guidance on identifying, valuing, and recording of non-current assets. The costs of annual financial reporting, includes the cost of staff directly involved in formulating the reports, possibly consultant’s costs, external auditor’s costs and delay costs for the business, are borne by the LGA (Local Government Authority). An outcome of this financial reporting is a single ASR (asset sustainability ratio) that includes all infrastructures. The usefulness of this ASR warrants consideration. The ASR is based on depreciation and this depreciation can be calculated in various ways to produce different ASR. This reporting leeway limits the comparability of ASR between different LGAs and puts in question the usefulness of reporting an ASR [2]. A case study found different reporting definitions, led to reporting differences, questioning the value of the report itself [3].

In the Australian State of Victoria, the Towong Shire Council uses the Moloney Asset Model to help manage Council’s assets and determine its level of expenditure on asset renewal. The model has been developed by an independent specialist in the field of asset management and is widely used by Councils throughout Victoria [4]. This model allows for the rating of assets including pavements on a zero to ten scale (zero being new or perfect). For financial reporting purposes, the pavement with zero condition rating has a WDV (written down value) of equal to the replacement value, while a condition rating of ten delivered had a WDV of $Nil. Now a variable exists that sets the condition rating between three and ten at which the WDV would reach zero but normally be within the three to ten condition range. This is further support for the question of the usefulness of the current financial reporting system for road networks [5]. Another feature of this model is that financial depreciation can occur after the WRV has reach $Nil (There is a Yes/No option to set Annual Depreciation to zero when WDV equals zero). This further questions the usefulness of financial reporting for road pavements by reducing the comparability between the figures due to different calculation methodologies for the results in these reports [5].

NRAs (National Road Administrations) across Europe continually attempt to improve the performance of their road networks. This improvement has been supported by significant research in the optimisation of road planning, design, construction and maintenance, which has improved the understanding of the social, environmental and economic aspects of managing a road network across European countries. However, there is common understanding in some aspects of sustainability, not a common understanding of sustainability as a whole and therefore how to benchmark and improve overall performance [6].

Neshkova and Guo [7] concluded “that public participation is, in fact associated with enhanced organisational performance”. By understanding the local conditions and costs, local leaders can provide transparent reports on the sustainability of their road network to state governments. Supported by calibrated systems, they are adept at determining road conditions and what best suits their community, economy and financial circumstances [8].

3. Sustainability Reporting in Queensland

Local governments in Queensland Australia are required to report annually on their sustainability to the Queensland Government. Sustainability reporting includes the ASR (Asset Sustainability Ratio). The ASR (expressed as a percentage) is an approximation
of the extent to which infrastructure assets managed by a local government, are being replaced as they reach the end of their useful life [9]. The current Queensland State Government Asset Sustainability Ratio is calculated in Eq. (1).

$$\text{ASR} = \left( \frac{\text{CapERA}}{\text{DepExp}} \right)$$  \hspace{1cm} (1)

where:

- \text{ASR} is asset sustainability ratio;
- \text{CapERA} is capital expenditure on replacement asset and;
- \text{DepExp} is depreciation expenditure.

Issues with the ASR include: that it does not include maintenance expenditures. Depreciation can be calculated with different results. All asset classes are combined. There are different depreciation methodologies and consequently reported figures vary but comply with IFRS (International Financial Reporting Standard). Due to the depreciation methodology being optional, comparability between local government’s financial reports is not transparent. The capital expenditure is a function of the political will from financial years prior to the reports being published. The ASR is backward not future focused. The ASR is, financially reporting based, not based on best engineering practice. The ASR does not report the condition of the road network. The ASR does not report the road network condition that the community is willing to fund. The ASR does not justify a future budget to maintain the road network condition that the community is willing to fund. The ASR does not report what the environmental impacts the capital expenditure will cause nor any mitigation that could occur.

4. Need for an SIR (Sustainability Index for Roads)

The justification for SIR is the relativity of the value of road network that is very high compared to other local government assets. In the United Kingdom, the TRL (Transport Research Laboratory) reported that “The Current UK Highways Agency asset alone is worth over £60 billion making it the UK Government’s largest single asset” [10]. In Australia, pavement represents 61% of the non-financial assets of local governments [11] and depreciation accounts for approximately 25% of the operating costs of local government but is a non-cash item [11]. A Logan City Council 2014 Asset Management Plan reported that Roads and Drainage assets accounted for 56% of the LGA assets replacement value [12].

5. An SIR and the Three Pillars of Sustainability

The SIR is a new model, uses the best engineering knowledge available, provides future annual budget implications of all three pillars of sustainability and is easy to implement.

5.1 Best Engineering Knowledge

The SIR is based on the outputs of calibrated pavement management systems. Local councils in Australia have been using pavement management systems since at least the 1990s. To have a reliable PMS it must, be loaded with accurate data, have a rulebase that recommends treatments that are applicable to the local workforce skills, plant and materials, have deterioration factors that have been calibrated for the local environment and have the works program “ground proofed” by an experienced pavement engineer.

The local government studied for this paper uses the SMEC (Snowy Mountains Engineering Corporation) PMS. The SMEC Pavement Management System is considered suitable, justified by it being used fifty-one LGA in Australia. SMEC operates (including local company names) in Australia, New Zealand, Africa, South Asia and Middle East, Asia Pacific and both North and South America [13, 14]. The local government data used in this paper has had the PMS deterioration factors calibrated as part of the South East Queensland, LTPP (Long Term
The SMEC PMS like others, can produce future works programs using different scenarios such as fixed or varying budgets and targeted Pavement Condition Index (PCI), for any future year (Fig. 1). The PMS scenarios can maximise the future road network condition by selecting those treatments that comply with the local government’s rulebase, to improve the condition for specific road blocks at the minimal cost most. The output is an annual works program for each year of a scenario, which matched the scenario chosen. The total cost of the works program will match the provided budget. Alternatively, if the scenario was set to a specific PCI, the total cost of the works program will match that needed to achieve the targeted PCI.

5.2 Annual Budget Implication—Financial

It is reported that road pavements have a non-linear deterioration [15]. Unlike other civil assets, pavements can be easily inspected and treated to bring back to an acceptable condition through maintenance or rehabilitation treatments. Other assets, such as stormwater pipes, are not as easy to inspect or carry out any works. When the pavement condition index in Fig. 1 is viewed in third dimension, a new curve is presented (Fig. 2) [16]. The equation of this curve defines the Return on Investment (RoI) for this road network, in terms of future PCI versus annual rehabilitation budget.

For a road network in this study, any future year can be considered but in this paper the results for the year 2025 are presented in Fig. 3 [16].

The annual budget implication (Financial) can be considered as a Return on Investment for the year 2025 Pavement Condition Index (average for the road network) with a consistent budget to the year 2025.

5.3 Annual Budget Implication—Social

While Fig. 6 provides an RoI in terms on PCI for budget allocation [16], the local community and legislators will want descriptors of what PCI means and this is provided in Table 1 [13, 14].

This paper proposes that the RoI, presented in Fig. 4, provides a basis for explaining to the community (they pay our salaries and fund road maintenance) what the target condition of their road network could be [16]. Note; no attempt has been made to steer towards an increase in future budget. Fig. 6 shows that the RoI is not linear, therefore while

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Fig. 1  Calibrated PMS prediction of pavement condition index over time with alternative budgets.
it appears intuitive that the community want their road network maintained to a high standard, the question arises as to what level of quality they are willing to fund?

In this case study, there was a target PCI set by other means at 8.5 [17]. The PCI descriptors and the target PCI were overlaid in Fig. 6, to form Fig. 7. It can be clearly demonstrated that setting a Target PCI in the Asset Management and Services Plan at 8.5, without considering the RoI, can lead to unrealistic targets that will not be funded and reduce the confidence in the engineers that operate the pavement management system. The RoI was not publicly available in 2014.

By providing Fig. 7 to the community, the annual budget implication from a social perspective could be better understood and a future PCI with community support could be determined.

5.4 Annual Budget Implication—Environmental

Local government annual road rehabilitation works, while a necessity, have negative impacts on
the environment. There is potential, at a financial and/or condition cost, to reduce these environmental impacts, by not using the most environmentally damaging road rehabilitations treatments. To calculate this cost, it is necessary to remove these treatments from the PMS rulebase and then rerun the PMS to get a new works program. From the new series of predicted PCIs, a new RoI curve is calculated. When the original and new RoI curves are plotted, the financial cost (horizontal difference between RoI curves) and reduction in pavement condition (vertical difference between RoI curves) can be demonstrated.

The research plan is to create a matrix of road rehabilitation treatments and their corresponding GHG (greenhouse gas) production, water, gravel, bitumen, cementitious materials consumption. The road rehabilitation treatments (same standard axle design figures) will then be ranked in order of most environmentally damaging. The PMS rulebase will then be edited to remove the most environmentally damaging road rehabilitation treatment and the RoI curve recalculated. This process will repeat for a second road rehabilitation treatment. The three (all treatments, no worst and no second worst) curves will then be presented in a single graph. Using this graph, the community can easily see that the extra annual financial cost and the reduced future PCI, of reducing the environmental damage by annual road rehabilitation programs.

5.5 Easy to Implement

The implementation of the SIR does not require any new tools and expenditure. The methodology has been developed (environmental in progress) as part of a Ph.D. by research, by a single engineer and can be duplicated by any local government.

5.6 Limitation

The prediction capability of the SMEC PMS is that it is limited to sealed flexible road pavements. In Australia, the vast majority of the road network is composed of sections with flexible pavements.

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