Improving unsealed road performance management systems to enhance sustainability

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ABSTRACT: *This paper is aimed at road asset managers, public works engineers, operations team leaders and sustainability managers working with local authorities. It discusses how, when it comes to sustainability, current assessment of infrastructure performance in Local Councils and public works might be acting as perverse incentives.*

Performance, as it is often defined as a concept, is based on unlimited growth, budgets and resources. However, Local Councils are faced with reduced finances, ever-increasing levels of expectations from residents, higher cost of resources and few useful tools and strategies to support them transitioning to this new reality.

The paper is based on a series of case studies conducted in Local Councils in Victoria in 2013/14, in collaboration with Earthco Projects Pty Ltd, supplier of PolyCom Stabilising Aid®.

Road maintenance teams, eager to evaluate a new approach to unsealed road stabilisation, examined project data, which would take into account life cycle and sustainability thinking. They compiled some empirical data on the usage of PolyCom Stabilising Aid®, but wanted to have a more thorough review of the environmental, financial and social benefits of using the product.

Preliminary findings point to a difficulty to track, store or report on such data. When reporting frameworks are in place, they track performance based on quantitative information such as kilometres graded, volumes and lengths. The "real" cost of machinery, fuel, water and material is lost in operational expenditure and not accounted for on a "per project" basis.

Participants found that information related to the reduction in the number of maintenance tasks, life cycle costs, incidents and resident complaints were not tracked. This is a significant finding, which provides critical information required for Local Authorities to report on their ability to support sustainable operations now and in the future.

KEYWORDS: unsealed roads, road stabilisation, sustainability, lifecycle, road maintenance, performance monitoring, asset management, sustainable infrastructure, perverse incentives, data capture.

1 Introduction

In this paper, we will review the barriers to the understanding and measurement of sustainability benefits in road maintenance projects using Earthco Projects Pty Ltd case studies as the source material. A review of current measurement of sustainability benefits in projects will be covered then used as a basis to observe and compare current practices around performance of projects and teams. Where possible, an overview of perverse incentives, which can hinder sustainability practices, is provided.

A range of recommendations is finally proposed which can support road management authorities in changing the status quo, and integrate sustainability as part of staff training, performance management and project monitoring.

2 Background

Earthco Projects Pty Ltd has been engaging with its clients in order to help them develop an awareness of the sustainability issues which characterise the type of activities involved in unsealed road construction and maintenance.

They provide solutions to resolve them and get involved with the training and education of the workforce.

Earthco Projects distributes a road stabilisation product, PolyCom Stabilising Aid®, which is environmentally inert and listed with ECO-Buy in Victoria and Sustainable Choice in NSW.

PolyCom Stabilising Aid® is a bio-based product, a polymer used for soil stabilisation. It is used in extremely small quantities and achieves superior results in a range of different conditions in the treatment of unsealed roads. Treatment with PolyCom instead of re-sheeting has proven to achieve significant benefits for local road authorities as demonstrated in a range of case studies conducted over the past few years (Table 1).

Most of the sustainability research conducted between 2010 and 2013 by Factor Ten Eco-Innovation for Earthco Projects was based on qualitative data, and aimed at measuring and comparing PolyCom Stabilising Aid® lifecycle impacts vs. that of re-sheeting when maintaining unsealed roads.

Following the conclusion of a previous paper (Camarena[1]) on the benefits of using new technologies for sustainable road maintenance, the research in 2013-14 was solely based on data capture and the barriers to lifecycle thinking and accounting in road maintenance projects.

Table 1: Comparative study of PolyCom Stabilising Aid® with traditional method of re-sheeting of 1km unsealed roads over one year

Comparison Description	PolyCom Stabilising Aid® treated	Traditional method of re-sheeting
Re-sheeting activities	741 kg of CO_2-e per km	7,160 kg of CO_2-e per km
Water usage	116.40kL	600kL
Comparative lifecycle costs study	70% savings on average	

In 2013-14, the aim of the research was therefore moved from an emphasis on quantitative data to one of qualitative data.

3 Assessment of road maintenance performance

Road maintenance can be assessed in terms of programme delivery, quality of the outcomes or user satisfaction.

Considering the long-term sustainability of infrastructure projects means that performance also has to be measured for:

1. Environment and economic decision-making
2. Public engagement
3. Decision for long-term environmental performance
4. Construction planning
5. Planning for lifetime monitoring and maintenance

In a context of tight financial constraints, sustainability is expected at all levels of the decision-making process (Hes D and Bates M[2]).

An overview of the performance indicators available to monitor road maintenance in Australia shows that sustainability data is not currently captured uniformly. And where it is found, it applies in the vast majority to the

design and construction of sealed roads (AustRoads[8], VicRoads[10]).

However, this case study focuses on unsealed roads.

Road Maintenance Programmes

Road management plans define asset classification, levels of service and maintenance management systems. These set the plan for definition, monitoring and assessment of performance of maintenance programmes.

In practice however, this means that numerous teams work from a spreadsheet of all the local roads and a list of the planned maintenance for each segment, which becomes the background for the work scheduled throughout the work "season". This schedule of work is affected by emergency work following a resident complaint or a routine inspection. Once the work is completed, the team continues with the planned schedule and the maintenance cycle re-commences year after year.

Data Capture

Key performance indicators usually monitored are mainly based on skid resistance, corrugations, potholes, public complaints and public perception, roughness and strength (deflection).

Earthco Projects has previously decided to apply the GreenRoads[12] rating criteria to support and measure its sustainability efforts. This covers data in the areas of: raw materials use, fossil fuel use, water use, greenhouse gas emissions, waste volume and life-cycle costs.

Ownership of the data

Most of the type of data required might be directly a responsibility of the sustainability, facilities, asset, and procurement teams or in many cases, a supplier's responsibility. This means that nobody involved in the road project has a wider view of the project data and can connect the bits of information together to form a true lifecycle-based picture of the project sustainability credentials.

Performance Assessment

When it comes to sustainability, performance across the lifecycle is what needs to be accounted for: Costs over the lifetime, but also "impacts of materials, design, site impacts, transient impacts and lifetime issues" (Pears[3]).

These requirements are also supported by an outcome-oriented approach to maintenance assessment. In the Table 2 below, the National Cooperative Highway Research Program[9] indicates improvements needed to the traditional assessment methods.

The Karlaftis and Konstantinos[11] adds to this the urgent need to review the performance-based model of contracting where long-term performance, outcomes and targets drive payments rather than amount of work undertaken.

Throughout the case study, current practice and desired approach has been used as a guide.

Table 2: Differences between traditional and enhanced maintenance activities

Type of Change	Traditional Approach to Maintenance Activities	Enhanced Approach to Maintenance Activities
Access to Information	All information processed through central office	Information accessed remotely with new technology
Information Used to Make Decisions	Subjective condition assessments	More objective condition measures
Types of Performance Measures Used	Output-based measures that record accomplishments (such as amount of material used)	Outcome-based measures that report results achieved (i.e. time until a clear, snow-free surface is provided)
Importance of Customer Expectations	Performance targets are more task oriented	Performance targets are based on customer feedback and expectations
Amount of Planning Conducted	More reactive	More proactive
Preparation of Budgets	Adjustments made to previous years' figures	Budget needs estimated based on existing and targeted levels of service

4 Case Study

Background Information

During the course of this project, the author and Earthco Projects have collaborated with the following Councils: Cardinia, Mildura, Loddon, and a range of other councils based in Southern Victoria, Northern Victoria and Southern NSW.

The initial approach was to discuss the creation of comparative data for road maintenance activities using traditional methods of re-sheeting versus using PolyCom Stabilising Aid®. In this case study, the focus was more on the reporting tools available, if any, than on the maintenance activities themselves.

The project started in October 2013 and is ongoing as of June 2014. However, observations made during the 2011 to 2013 period for the evaluation of PolyCom Stabilising Aid® have also been taken into account.

The participating councils were asked to provide a basic list of road projects. Projects selected would be classified in three categories: recently completed, in the process of being completed and to be completed.

They were also asked to provide evaluation data on how projects are individually performing and, if possible, how the whole program of work was performing. The focus for performance evaluation was to compare traditional methods of re-sheeting versus using PolyCom Stabilising Aid®.

Using Earthco Projects' clients as the basis for the study, a data capture template was developed which the participants used to help evaluate full life cycle benefits. This constituted a baseline for the gaps analysis of performance monitoring practices.

The work required with the different case study participants turned out to be significant and the rate of data gathering much slower than expected due to inherent system limitations.

However, the difficulties are themselves a great insight into the current approach and the changes required to create an industry much more in control of its sustainability impacts.

Therefore, we have chosen to report on them these difficulties in the interest of enabling road authorities to undertake a more sustainable method of road maintenance.

Aim of the Research

Working collaboratively with their clients, Earthco Projects was concerned that the breadth of results some councils observed (Table 1) were not always replicated in the data gathered in other councils. They were curious to find out why, and started working with a broad range of PolyCom Stabilising Aid® clients to gather data to that effect.

The main aim of the research was therefore to acquire data on the performance of road maintenance where the road was treated with PolyCom Stabilising Aid® rather than the traditional method of re-sheeting.

The overarching principle was to obtain a full lifecycle-based picture of all the impacts and results of the PolyCom-treated roads.

The process of gathering the data, identifying the gaps, providing support to the work officer's teams and their managers was observed and reported upon.

Lifecycle thinking: a challenge

Work teams are following a maintenance regime, which involves cyclic activities, local knowledge and routine inspections. They also have to contend with other (public, political, commercial) priorities.

They often have to make decisions on the spot depending on the weather (more or less water), the properties of insitu material (plasticity), etc.

They are job-focused and under pressure to act quickly to reduce the traffic disruptions and ensure the safety of road users.

This ability to focus on the job to be done is what makes them efficient.

However, what is required of a lifecycle thinking approach is to have the full picture of the works impacts.

For example, one of the key benefits of PolyCom Stabilising Aid® is that it can be used with insitu material as opposed to the unsustainable method of importing virgin materials in the maintenance practice of re-sheeting unsealed roads. In addition, the impacts of quarrying the material and transporting it to site is not accounted for. This is a significant omission because material production alone represents on average

around 30% of the project total carbon emissions. Finally, other impacts which are difficult to measure but are critical are not accounted for such as: damage to adjacent roads, disruption to residents along the route taken by quarry trucks, cost and fuel emissions of material transportation (often quarry owned).

Report in silos

The participants have limited resources to conduct these studies. Staff are fully occupied performing road maintenance works. Sustainability and reporting skills are limited.

Data on section length, width, number of gradings in the previous period, cost of maintenance and overall comments on performance and dust emissions are often captured.

Onsite, the teams do not generally have access to records of specific use of material, km travelled and fuel use of vehicles. Provision of the material such as quarry distance, and impacts of transport for quarry material is not readily available.

Information required to get a full picture of the lifecycle impacts and costs of projects resides in different departments other than the road maintenance team.

Cost of plant and machinery is often the responsibility of the asset management team.

The environmental team reports on fuel emissions but data is not easily accessible by the road maintenance teams.

In some cases, the supplier of quarry material includes the cost of transport in the cost of material and no information on the fuel carbon emissions is available to the road maintenance teams.

Information on number of vehicles for each road might be available from the asset management team but not always and not necessarily for the specific sections of roads treated which makes comparisons over time difficult.

Some costs and impacts are completely hidden from view. When Councils decide to subcontract the grading works, suppliers own the information, therefore it is invisible to the work teams. However, the responsibility of the works is the Council's and the impact of its decisions in terms of maintenance regimes should be transparent.

Observation vs. measured results

Capturing data to support observable results became an important part of the case study. This implied that the participants and Earthco Projects had to devise and develop new testing methodologies.

An indirect benefit of using PolyCom Stabilising Aid® has been an observable reduction of dust emissions with some Councils deciding to abandon the treatment of roads with magnesium chloride in favour of PolyCom. They observed that roads treated with PolyCom emit less dust.

However, lacking demonstrable results, it was decided that a testing procedure be put in place. Earthco Projects Pty Ltd has instigated with its clients a ravel test procedure, which will help quantify the amount of material loss before and after the treatment of the road.

Due to the nature of the work (reproducible sample of same road section over a defined period of time), the ravel test is simple to run and the data (grams of loose material) provides sufficient information for a basic level of comparison.

This constitutes a good example of the actions taken during the project to obtain valid data.

Defining performance

The concept of performance for road maintenance can vary greatly from one organisation to the other.

Example of performance indicators for road maintenance projects can be (Main Roads Western Australia[6], AustRoads[7]):

- % of projects completed on time
- % of projects completed on budget
- % of availability / disruption to the network
- Average $ cost of network maintenance per lane kilometre
- Response time based on road classification
- % of completion of planned work

Some road authorities measure community satisfaction and smooth travel exposure (based on International Roughness Indicator) but this is not true in many of the smaller Local Authorities.

When it comes to unsealed roads, response time and maintenance regime is set for: rutting, pot holes, corrugations, surface scour, loose material and coarse surface (East Gippsland Shire[4], Cardinia Shire[5]).

In reviewing the performance assessment of road maintenance projects, an interesting find was the reflection on what was missing rather than what was readily available.

Weather conditions can severely affect the schedule of work (floods, droughts) and this was not monitored consistently and in the context of road maintenance performance.

Drainage has a critical impact on the quality of the road maintenance. The presence of shade (trees) or agriculture (crop watering) influences the quality of the maintenance and the maintenance regime. However, the information on this is mainly local knowledge by local staff. It is difficult to capture data around these impacts and to draw long-term lessons from it.

Performance indicators did not account for an evaluation of the maintenance programmes over time (span of several years or decades), which prevents a lifecycle view of the asset. For example, it is widely reported by a number of Councils that by using PolyCom Stabilising Aid®, the number of grading interventions over time is reduced, therefore reducing cost, material required, disruption, water and carbon emissions of projects. There was no option to validate this in a number of projects where no long-term historical data was available.

No reporting of lifecycle performance is in place and the data, which would allow a comprehensive lifecycle view, is scattered across a range of systems and departments.

In cases where sub-contractors were used, the performance criteria were often based on the number of gradings per year (output-based). This is in itself a symptom of a short-term view and constitutes a perverse incentive, “an incentive that has the opposite effect of that intended”. Sub-contractors might find an incentive in grading a road, which might not necessarily need it because it is part of their revenue model. Work might need to be redone more often because there isn't enough incentive to make it last.

Strategies and Recommendations

Data capture templates were developed and used with Earthco Projects' clients, which can be filled in on site or backfilled after the jobs were completed. The templates where adjusted based on the clients' feedback to become as practical as possible.

The ravel test procedure is one of the strategies used to gather empirical data, which will inform the lifecycle benefits of using PolyCom.

Mentoring of clients is a critical area for Earthco Projects and the time spent on site has been central to the lifecycle thinking approach Earthco Projects has adopted.

Removing the silos is a challenge of its own and has required a range of strategies around communication of the goals, clear identification of what is required by each department or stakeholders and data specification details.

Focusing on a few areas rather than trying to resolve all the issues has allowed visible progress on a few elements. For example, if the machinery is the property of the Council, we have worked to include the fuel consumption and costs per vehicle in our project data. If the machinery is owned by a subcontractor, the focus is placed on identifying the type of vehicles used only. Data on fuel and costs can be added later.

The perceived benefits are not quantifiable in dollar value. More often than not, it comes down to residents’ feedback and how it has evolved over time (before and after using PolyCom Stabilising Aid®). Data collection on the number of complaints/merits for sections overall has also commenced with the aim of doing so for sections of roads in the future.

Letting go of what is not known is an important part of the process. Whilst the intent was to collect information which would allow the benefits of PolyCom Stabilising Aid® to be compared in detail with that of traditional methods of re-sheeting, it became obvious that an inordinate amount of time could be spent reverse engineering projects. Agreeing that data capture from here onwards is satisfactory and that it is the basis for future quality decision-making is crucial.

An openness to innovation based on trust and guided by life cycle thinking has allowed innovative ideas to come to the forefront. For

example, Earthco Projects is currently examining the use of PolyCom Stabilising Aid® mixed with fines and loose material accumulated in drains. If successful, the efforts of the teams will result in hundreds of thousands of dollars in savings, and improvements in drainage throughout the road network, amongst other achievements.

Sub-contractors and suppliers tender requirements should be formulated with outcomes as the indicator rather than input/output. Long-term outcomes, staff skills, environmental indicators should be part of the contract specifications.

A vision of what the end result would look like has been created, which includes a view of material impacts, transient, usage and disposal impacts. This vision also includes elements of quality (ride comfort, vehicle fuel efficiency) and safety. This has helped share the goal, the desired outcome, and allowed a framework for the participants to provide input and knowledge on how it could best be achieved.

Lastly but most importantly, the willingness, skills and enthusiasm of the participants, works officers, engineers and managers are at the centre of innovation and progress.

5 Conclusions

Performance can no longer be based on traditional methods of maintenance assessment if sustainability is to be evaluated fully.

A long-term view of benefits, strategies and methods is required, guided by lifecycle thinking. The road network management is affected by maintenance decisions.

The maintenance of the unsealed road network should be seen as a service rather than a product.

PolyCom Stabilising Aid® is currently being tested for performance and sustainability by a team of researchers at Swinburne University of Technology. This has the potential to develop new Australian standards of testing protocols.

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