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The Best Practices for Sustainable Infrastructure

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ABSTRACT

In this study, the best practices are provided to help engineers/managers in solving the infrastructure gap through good planning and utilization of available financial/staff resources, efficient and effective use of the available fund, exploration of new and alternative/innovative but economical method of construction and preservation, prioritization process, and innovative fund generation. Better communications between technical staffs and non-technical higher management as well as municipal council (elected or appointed) and building the public supports also influence funding decision/allocation.

Keywords: *sustainability, infrastructure asset, funding, survey questionnaire, preservation, prioritization process*

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INTRODUCTION

Existing municipal infrastructures are ageing while demand is growing for more and better roads, improved water and sewer systems, etc. The infrastructures are renewed on a specific interval of time, but these are deteriorating more frequently before the renewal takes place. The money allocated for the renewal is not sufficient. Several factors have impacted on municipal infrastructure. The factors include deficient funding, demographic explosion, strained condition in environment, health essentials, weak quality control which results in inferior installation, below par inspection, unsatisfactory maintenance, lack of consistency and uniformity in design, construction and operation practices. At the same time, significant growth in some sectors accelerating the ageing process, due to an increased burden/load on infrastructures, while increasing the social and monetary cost of service disruptions due to maintenance, repairs or replacement.

On the other hand, infrastructure competes for funds with other corporate priorities such as police, fire, social services, parks, recreation and libraries. These sectors often receive higher priority for funding and the net effect of this situation is a chronic deficiency in capital budgets for infrastructure. In Canada, the infrastructure maintenance deficit has been estimated to be over $44 billion and this figure is climbing. This shows, in general, that municipal hard infrastructure is not getting its fair share of funding and the funding deficiency has reached to the point that infrastructure, both current and new, is rapidly deteriorating. Ideally, each infrastructure should be funded based on

demonstrated need, i.e. need should drive funding. An innovative solution is therefore required to face the challenge of funding limitation and infrastructure needs.

PLANNING SUSTAINABLE INFRASTRUCTURE

The National Guide to Sustainable Municipal Infrastructure (InfraGuide) is a new initiative to meet these challenges and change the way infrastructures are being planned, designed and managed. It is a national network of expert people and ongoing compilation of Canadian best practice experience and knowledge/research publications. These best practices attempted, by simplifying complex and technical material into "non-technical" decision-making concepts and principles, to articulate the relevance and fundamental importance of municipal infrastructure. By doing so, it is anticipated that the need for adequate sustainable funding for municipal infrastructure can be understood and ultimately realized [1].

The decisions and actions for sustainable municipal infrastructure are supported by the best practices in six key areas. These are municipal roads and sidewalks, safe drinking water, storm and wastewater, planning for decision-making and investment, environmental protocols and transit [2]. The motto is bottom-up approach, knowledge sharing, Canadian experience and research, national cooperation and participation. The objective is to offer the Canadian best experience and knowledge of infrastructure and help decision-makers and technical staff in the public as well as private sectors to:

- Make informed and smart decisions regarding maintaining, repairing and upgrading the infrastructure.
- Maintain higher standards of safety, health and environmental protection.
- Meet the challenge of increasing infrastructure demand by both of quality and quantity, deterioration and decreasing level of service.
- Overcome the challenge of shortfall in funding.

It is expected that the municipal infrastructure issues would be represented by the high-level, simple, easy-to-understand approaches and concepts. These approaches and concepts would optimize municipal infrastructure management practices. These practices can be the best practice guides which may motivate decision-makers. In this way, a gulf will be bridged between the non-technical and the technical communities of public works officials and engineers, which is very important in decision-making and funding allocation.

Proper demonstration of the infrastructure's actual need and consequences of failure to act based on demonstrated needs would also influence the municipal budgeting process. This would act as a catalyst to get fair share of municipal funding for the hard infrastructures. Engineers/managers should therefore be prudent to present the actual picture of the infrastructure and forthcoming result of the negligence. Engineers/managers should also demonstrate their capability in utilizing the available or committed funds and develop/suggest mechanisms of generating alternative funds. These are the ways the engineers/managers can work for reducing the infrastructure funding gaps. The InfraGuide's accumulation of best knowledge and expert guidance is expected to guide municipal engineers/managers in these regards and help to reduce the funding crisis as well as best use the available resources [1]. The overall conclusion or bottom line is that each city needs a good and effective asset management system.

INFRASTRUCTURE NEEDS

This best practice guide focuses on planning and defining goals and needs of infrastructure such as roads, water, wastewater and sewers. This guide provides municipalities the basics for developing, analyzing, communicating and presenting the needs for infrastructures. It also incorporates economic, social as well as environmental and sustainability issues into long-term strategic planning of the infrastructure. The best practice guide identifies and describes five methods of potential interests to municipalities. These are strategic planning, information management, building public support and acceptance, exploring new and innovative methods for continuous improvement, and prioritization models. The strategic planning method points to the development of integrated vision and strategy. This vision leads to an official community plan, an infrastructure plan, an economic plan and a financial plan. These subsequently drive all developmental and operational plans enabling the municipalities develop and operate or limit development within an established framework of well-defined priorities and their capacity to service infrastructure. Such framework is vital to the successful operation of any municipality and sustainable development.

Information management method uses the information systems as inventory programs that feed into planning needs. The concept involves software/database systems that include annual data on condition assessment, demand, usage, risk assessments, condition prediction, etc. Such systems facilitate municipalities to log-term plan their needs and set investment priorities through asset understanding in the context of life cycle and integration within strategic framework. The benefit of having such system is judged to be great, since it provides full jurisdiction for project prioritization using established criteria. This also facilitates information exchange with decision-makers and allows the municipality to be aware of risks and liabilities associated with infrastructures condition and their action [3].

The public is the primary stakeholder, since they use it, and pay for infrastructure, and therefore public involvement in infrastructure decision is important. Several mechanisms for obtaining feedback from public were indicated in this context including polls, mail/phone surveys, open houses and focus groups. Such public consultative approach can help the municipality in many ways: gain knowledge of public satisfaction levels, get public's opinion on municipality's vision, strategy or policies and refine them, identify areas of specific service that need to be improved, gauge specific reactions for potential rate or tax increases, open and transparent decision-making, help establish the level of service, etc.

IMPROVEMENT METHODS

Exploring New and Innovative Methods for Continuous Improvement is a proactive approach that refers to a diverse range of management approaches for innovative infrastructure management. Examples are allocating staff or resources strategically to improve the analysis of infrastructure options or demonstrating an ability to explore new innovative infrastructure solutions in the form of pilot projects or approaches to focus on risk management or self-assessment.

Prioritization models include weighing and ranking systems, linking capital with O & M budgets in planning, and business case approaches. Weighing and ranking is a corporate prioritization process through multi-factor qualitative assessment that

leads to a result-based decision to infrastructure prioritization. Linking capital with O & M budgets is an analytical process in project planning that reviews and estimates the full life-cycle cost of a capital investment. This allows to make better decisions in capital project planning, i.e. project is approved once funding strategy in place. Business case approaches are typical private sector approaches which recommend the best technological option at the best price, or the best value for money approach. This enables the municipal council or higher management to make sound decisions by comparing a series of options including doing nothing.

This guide will assist many Canadian municipalities, where current infrastructure needs are not being addressed, to coordinate infrastructure needs and municipal financial priorities, shape and influence the type of growth, optimize or maximize the use of existing infrastructure, plan for optimal rehabilitation, and manage the demand on infrastructure through change in user behavior. The knowledge of the above practices is quite valuable to meet needs of all municipalities, big or small, and achieve goals that include environmental stewardship, social conscience, economic opportunities and fiscal responsibilities. This best practice guide, therefore, may be regarded as a strong information base with valuable idea for the municipalities facing new pressures or increased complexity in infrastructure decision. Examples of municipalities, using these approaches in planning and decision-making, strengthened this guide database for information sharing among the municipalities [1, 4].

The weakness of the guide is lack of comprehensive examples. The guide should include full case study, instead of just examples with short brief, to enhance the usefulness of the guide. Expert analysis of each example case with focus on methodology/tools used, benefit gained, or problem faced with analysis of inherent reason and advice on how this could be avoided or steps for potential improvement would make this guide a unique creation of knowledge base [5]. Also, example cases in chronological order of application/implementation (e.g. date/year of use), current status, benefit gained and actions taken to handle problem (if any) in implementation of the stated methods instead just "mentioning recent ones appear to be more practical (on page 27 of the guide)" would help readers to identify the most recent one and give more attention to potential use of those methods/tools.

ASSET MANAGEMENT SURVEY

The survey should start with an introduction of the initiative of the survey with questionnaire attached to it. The introduction of the survey followed by survey questionnaire is presented in the Appendix.

The National Guide to Sustainable Municipal Infrastructure (InfraGuide) is developed in 2001 by the federal government, through its Infrastructure Canada (IC) program and the National Research Council (NRC), joined forces with the Federation of Canadian Municipalities (FCM). InfraGuide is a national network of people and a growing collection of published best-practice documents. It is mainly for the use by decision-makers and technical personnel in both the public and private sectors. Based on experience and research in Canada, the reports set out the best practices to support sustainable municipal infrastructure decisions and actions in six areas, which are municipal roads and sidewalks, potable water, storm and wastewater, decision-

making and investment planning, environmental protocols and transit.

In course of its continuing effort to develop the best practice guide for various areas of infrastructure, the Roads and Sidewalks Technical Committee is planning to develop a best practice guide for the roads and sidewalks asset management practices by Canadian municipalities. As part of this initiative, the committee has decided to conduct a survey of the asset management practices by municipalities across Canada. The focus of this part is roads, bridges, signs, manholes, sidewalks, and curb and gutter. The attached questionnaire is designed for small- to medium-sized municipalities with population of 100,000 or less.

Some additional information may be attached with the survey on municipality's initiatives to maximize benefits of investment, reporting procedure, innovation in management strategy, infrastructure performance, information management systems, infrastructure coordination practices, etc. [6, 7].

The survey questionnaire would be augmented to capture the issues of sustainable infrastructure. In addition, information on local economic activities, trends, local culture, income levels, environmental conditions and effects, public concerns including surface characteristics and noise issues, council's initiatives that might contribute to asset management practices, asset classification by functional class, surfacing, etc., and levels of service criteria and performance standards for various classes would be gathered in this survey. An interview would follow to obtain broad pictures from selected municipalities.

INFRASTRUCTURE MANAGEMENT PRACTICES

While asset management practices apply to all types of municipalities, big or small, larger cities with a large network and complex systems of infrastructures would have a more dedicated and well-established asset management systems. They would generally have advanced technology/equipment for data collection and assessing their asset conditions, advanced information management systems for managing, evaluation, storing and sharing data. Larger cities with higher population, thereby higher growth, are associated with higher demand of infrastructures and higher funding deficit because rapid deterioration from higher use of the facilities, and growing demand for capital projects. Although there are prospects of higher revenue and alternative funding mechanism to finance the infrastructure needs, the shortfalls are also likely to be higher. This is since roads and associated physical assets generally do not have dedicated funding sources and fund supplies for these infrastructures do not run parallel to the needs. The larger the cities, more complex the problems are, since more people would mean more concern, more demand on facilities and demand for higher standards of performance levels. There will have more concerns on sustainability and environmental issues, pavement surface friction and traffic noise issues, etc. [2, 8, 9].

All these issues, discussed above, together ask for a more effective planning and decision-making process, efficient use of available resources, and preservation of the assets in a state that warrants good value and performance. This would require a large and structured, from field to very high level, administrative body to manage the assets and in the decision-making process [10]. The city would also need a system to evaluate the performance of the administrative body and project-level staffs in addition to evaluating the project outcomes. Large cities with its vast network of infrastructures and utilities

would also warrant a dedicated team for coordinating the infrastructure works. These cities should have well-organized planning and decision-making process, a business plan, strategic, network and project-level plans, a well-developed performance standards and specifications, policy for assimilation of new technology, multi-skill training program, a well-specified monitoring and reporting systems, and so on. The InfraGuide for asset management best practices for "roads, bridges, signs, manholes, sidewalks, and curb and gutter" should cover these issues, and the survey should be augmented accordingly.

CONCLUSION

For sustainable infrastructure, funding, population, environment, quality control, maintenance, and consistency and uniformity in design, construction and operation practices should be considered. All the management systems should cover planning and decision-making process. InfraGuide should include the existing infrastructure needs and municipal financial priorities, shape and influence the type of growth, optimize or maximize the use of existing infrastructure, plan for optimal rehabilitation, and manage the demand on infrastructure through change in user behavior.

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APPENDIX
ASSET MANAGEMNT PRACTICE: SURVEY QUESTIONNAIRE
(Roads, Bridges, Signs, Manholes, Sidewalks, and Curb and Gutter)

Personal Information:

Name: _____

Title/Position: _____

Signature: _____ Date: _____

Demography

Municipality Name: _____

Geographic Location: _____

Municipality Size: Area _____ (sq-km) Population: _____

Population Growth Rate: _____ (%) Traffic Growth Rate: _____ (%)

General

Asset Management Strategy: Yes ☐ No ☐ Infrastructure Inventory: Yes ☐ No ☐

Comment on above: _____

Long-term Plan: Yes ☐ Period (year) _____ No ☐

Comment on above _____

Municipal Revenue Sources: _____

Infrastructure Funding (million $):

Year	Federal Grant	Provincial Grant	Local Source	Total
Last 5-yr Avg.	_____	_____	_____	_____
Current Year	_____	_____	_____	_____

Infrastructure Annual Budget (million $):

Year	Needed (Estimated)	Allocated	Shortfall
Last 5-yr Avg.	_____	_____	_____
Current Year	_____	_____	_____

How Funds are Allocations for Various Infrastructures (Roads, Potable Water, Storm and Wastewater, etc)? : _____

_____

Public Involvement in Funding Decision: Yes ☐ No ☐ If yes, How? _____

_____

Pavements:

Total length of the Pavement: _____ km, Projected Need, year/ km _____

Total Investment ($):_____ Present Worth ($):_____

Road Management Strategy in Place: Yes☐ No☐ Comment _____

_____

Road Inventory Exist: Yes☐ No☐ Comment: _____

How Inventory is updated? :_____

Pavement Condition and Performance Evaluation Procedure: _____

_____

_____

Levels of Service Criteria or Condition Indicator in use?: Yes☐ No ☐

If used, indicate type, Scale and Use (user, functional or structural evaluation):

Indicator Type	Application	Overall Scale	Ranges for Different Conditions

Pavement Condition and Expected Remaining Service Life:

Pavement Age (year)	Length (km or %)	*Current Condition	Remaining Life (Year)	Municipality Actions and Plan
0-10				
10-20				
20-30				
Over 30				

*Based on scale used (e.g. very good to very poor, where very good means no user discomfort and very poor warrants the replacement).

Capital Investment ($): Needed _____ Planned _____ Shortfall _____

Basis for Project Selection: _____

_____

Life-Cycle Cost ($): Needed _____ Planned _____ Shortfall _____

Maintenance Strategy: _____

_____

Rehabilitation and Reconstruction Strategy: _____

_____

What is the acceptable level of service and associated risk?:_____

_____

What is the long-term plan associated with levels of service: _____

_____

Bridges:

Number of Bridges: Concrete____ Steel: ____ Others (Type/Number) _____

Total Investment ($) _____ Present Worth ($) _____

Bridge Management Strategy in Place: Yes ☐ No ☐ Comment _____

_____

Bridge Inventory Exist: Yes ☐ No ☐ Comment: _____

What data are collected? _____

_____

Data Collection and Recording Procedure: _____

_____

How Inventory is updated? :_____

Levels of Service Criteria or Condition Indicator in use?: Yes ☐ No ☐

Data used to rate bridge condition, performance and safety:

Type of Evaluation	Indicators and overall scale	Scale range of different conditions	Methodology for Condition Evaluation
User			
Functional			
Structural			

Data Evaluation and Response: _____

_____

Bridge Condition and Expected Remaining Service Life:

Age (year)	Bridge Type	Number or % of Total	Current Condition	Remaining Life (Year)	Municipality Actions and Plan
0-25	Concrete				
	Steel				
25-50	Concrete				
	Steel				
50-100	Concrete				
	Steel				
Over 100	Concrete				
	Steel				

Capital Investment ($): Needed _____ Planned _____ Shortfall _____

Basis for Project Selection: _____

Life-Cycle Cost ($): Needed _____ Planned _____ Shortfall _____

Maintenance Strategy: _____

_____

Rehabilitation Strategy: _____

_____

Reconstruction Strategy: _____

_____

What is the acceptable performance levels for bridges, associated risk and long-tem plan?:

_____

_____

Signs

Types and Materials:_____

Selection Criteria:_____

Criteria for Placement:_____

Replacement Criteria: _____

Manholes

Manhole Inventory: Yes☐ No☐

Types and Sizes: _____

Positioning Criteria: _____

Inspection Procedures and Associated Benefits: _____

_____

Condition Assessment and Maintenance Criteria: _____

_____

Level of Service Criteria: _____

_____

Sidewalks

Sidewalk Inventory: Yes☐ No☐

Sidewalk Type: Concrete _____ (%), Asphalt _____ (%), Others _____ (%)

Material Selection Criteria: _____

_____

Position Selection Criteria: _____

_____

Deterioration Monitoring Process and Benefits: _____

_____

Condition Evaluation Criteria, Acceptable Levels and Justification: _____

_____

Safety Considerations and Maintenance/Replacement: _____

_____

Curbs and Gutter

Curb and Gutter Inventory: Yes☐ No☐

Design Criteria: _____

Inspection Procedures and Frequency: _____

_____

Condition Assessment and Maintenance Criteria: _____

_____