



For the Record

Canadian Infrastructure Crisis Still Critical

CCPPP is frequently asked to comment on the state of Canada's infrastructure. Over the years, we have turned to Saeed Mirza's work in this area. Professor Saeed Mirza is Professor Emeritus of Civil Engineering and Applied Mechanics at McGill University. He was the Founding Chair of the Canadian Society for Civil Engineering's Technical Committee on Rehabilitation of Infrastructure and was Past-President of the Canadian Society for Civil Engineering (1984-85). He has published extensively in the area of structural engineering, engineering education and renovation and preservation of infrastructure. In particular, he has published several research reports on the infrastructure deficit in Canada, including most recently, "Danger Ahead: The Coming Collapse of Canada's Municipal Infrastructure" (Federation of Canadian Municipalities, November 2007).

CCPPP interviewed Professor Mirza in February 2009 about his opinions on the progress we are making in Canada and incidentally, to get a sense of how PPP might be used to address many of the current problems in conventional approaches to public infrastructure development.

What kind of state is Canadian infrastructure currently in?

Canada's infrastructure is in a very dire state.

Is current infrastructure reaching its full lifespan? Why not?

About 60% of all our municipal assets are over 55 years old. About 30% of the entire infrastructure in Canada is more than 85 years old. The life expectancy of a little over 80% of our infrastructure has been exhausted. This represents a very serious situation.

Based on your work with the Federation of Canadian Municipalities (FCM), what's your assessment of the municipal infrastructure deficit and the state of the existing inven-

tory of public assets at that order of government?

As of November 2007, the municipal infrastructure deficit is:

- To upgrade the existing deteriorated municipal infrastructure to an acceptable level: \$123 billion
- To construct new infrastructure to fulfill the new and changing needs of communities: \$115 billion
- Total upgrading and new municipal infrastructure needs: \$238 billion.

When the upgrading and new infrastructure needs for the provincial/ territorial and federal governments are added, the total infrastructure deficit for Canada could easily be between \$350 billion and \$400 billion.³

In 1995, most of the Canadian municipalities did not have any reasonable inventory of all infrastructure assets under their jurisdictions. This condition had improved considerably by November 2007; many more municipalities have inventories of most of the various assets under their care.

In 2003, the top objective (out of a total of 10 objectives) of the Technology Road Map was "to develop a reliable and accessible inventory of Canada's infrastructure, including location, condition and valuation that supports integrated asset management". In summary, there is a strong need for a GIS-based inventory of all infrastructure (municipal, provincial/ territorial and federal) in Canada, along with its construction and maintenance history, and its latest state of

1 The Canadian Society of Civil Engineering, "Civil Infrastructure Systems Technology Roadmap 2003-2013" (June 2003)

2 Federation of Canadian Municipalities, "Danger Ahead: The Coming Collapse of Canada's Municipal Infrastructure" (November 2007)

3 Extrapolation of the municipal infrastructure deficit to the provincial and federal infrastructure.

health, determined using nondestructive technique, to enable scientific management of infrastructure with currently available limited resources.

It should be noted that our infrastructure needs are way beyond what can be afforded by all levels of government. Therefore, the governments must acknowledge that Canada has a serious infrastructure crisis, and they must attempt to find innovative sources of funding, the best one being public-private partnerships (P3s). In addition, to improve the present management of infrastructure assets, the user must pay for all of the costs, including the depreciation of the assets, which is not even considered in many cases, until the facility falls apart (e.g. the water supply lines in Montreal).

With all the needs, do you have any sense of how governments should prioritize their investments in public infrastructure – what do you do first and why?

About 15% of our infrastructure, mainly water supply and sewers, are over 100 years old.⁴ The risk of failure in terms of health and providing good service, along with the need for rehabilitation and replacement, needs to be evaluated. The different levels of government should assign a higher priority to infrastructure facilities, which are presenting a higher risk in the near future.

Does one or other order of government (or agency of government) stand out as being better managers or custodians of their infrastructure?

There is no simple and direct answer; however, the following summary shows that the Federal Government needs to assume a higher level of responsibility and leadership for infrastructure.

In 1961, the share of infrastructure assets under the jurisdiction of federal, provincial/territorial and municipal governments were 39%, 36% and 25%, respectively. Presently, these shares are about 18%, 36% and 49%, respectively. This reflects a major shift in infrastructure responsibility to municipal governments. Also, presently, the share of the taxes with federal, provincial/territorial and municipal governments are 50%, 42% and 8%, respectively. Clearly, the municipal governments have the least resources to fulfill the needs of the largest share of Canada's infrastructure.⁵

In the 2009-2010 Budget Plan, the Federal Government provided a significant amount dedicated to the various categories of infrastructure. However, these numbers fall far short of the infrastructure renovation needs. It must be emphasized that Canada's infrastructure deficit is of the same order as the accumulated federal debt and therefore, it should be treated with the same seriousness as the accumulated debt.

This can be achieved through the federal, provincial/territorial and municipal governments and other stake-holders adopting a national infrastructure policy acknowledging the crisis and developing innovative solutions to combat the large infrastructure deficit over the next 15-20 years. The different levels of government must find innovative

funding sources, about \$20 billion to \$25 billion per year, to ameliorate the deteriorated infrastructure to an acceptable level and to develop the needed new infrastructure.⁶ The provincial/territorial governments should permit the municipal governments to raise the needed funds through suitable bond issues.

It should be also noted that the Federal Government was involved in building some large, nationally important projects, such as the CP Rail, St-Lawrence Seaway, Trans Canada Highway, the Confederation Bridge and many others, because the Federal Government was the only body which had the resources and the authority to act as an entrepreneur. No other public or private sector organization could have dealt with the level of entrepreneurship needed for these projects.

We like to talk in terms of sustainable infrastructure and emphasize the importance of setting up reserve funds in government to apply to the needs of normal and predictable maintenance regimes to get the normal expected life out of our infrastructure assets. Given the competing priorities in government, is it likely that government will ever have the ability or perhaps discipline to achieve full life realization of our public infrastructure?

The maintenance of any infrastructure facility would normally cost about 2-4% of the cost of the facility, depending on the age of the facility and its level of deterioration

4 The Canadian Society of Civil Engineering, "Civil Infrastructure Systems Technology Roadmap 2003-2013" (June 2003)

5 Harchaoui, T.M., Tarkhani, F and Warren, P., 2004, Public Infrastructure in Canada, 1961-2002, Microeconomic Analysis Division, Statistics Canada, Canadian Public Policy, Vol. XXX, No. 3

Federation of Canadian Municipalities, "Building Prosperity from the Ground up: Restoring Municipal Fiscal Balance" (2006)

6 Assuming that Canada's total infrastructure deficit is between \$350b-\$400b, eradicating it over 15 to 20 years would require an annual investment between \$20b and \$25b.

Table 1: Average Lifespan of Infrastructure Facilities

Asset	Life Expectancy
Bridges (required by the Canadian Bridge Design Code)	75 years (102 years in the UK)
Highways	25-30 years (longer in Europe)
Water/Wastewater Treatment Plants	50-60 years
Hospitals	75-100 years
Recreational Centres	50-60 years

due to any aggressive environment and the extent of use of the facility. The present philosophy of managing our infrastructure is to “design, build and forget”. This implies that the owner is concerned primarily about the first costs to design and construct a facility, without much concern for the operation and maintenance of the facility over its service life. There must be a paradigm shift and we must design a facility with due consideration of its performance over its life cycle. This implies that the designer should provide a detailed maintenance manual for the facility for its entire service life, as is done presently for automobiles and electrical appliances; the owner would also be committed to pay for the required maintenance and some rehabilitation when it is anticipated. Sustainable development would take us a step further and include the costs of facility decommissioning and demolition when it has outlived its service life.

What are the average lifespans of the following pieces of infrastructure if they are maintained properly: bridges, highways, water/wastewater treatment plants, hospitals, recreation centres.

The average lifespans of specific infrastructure facilities have not been clearly enunciated, except for bridge structures. The anticipated average lifespan for the various

infrastructure facilities are illustrated in Table 1 (see above).⁷

Is there existing research to demonstrate the impact of under-investment in infrastructure at critical stages of the lifecycle?

I do not know of any research reports relating to the impact of maintenance underinvestment at critical stages during the lifecycle of a facility. There are two theoretical works on record- by de Sitter in France with the Law of Fives, and the other through our work at McGill which is directly related to the Canadian infrastructure scene. We estimated that without regular maintenance, or with frequently deferred maintenance, our municipal infrastructure deficit can easily soar from the present \$123 billion to over two trillion dollars by 2067. The total cost of deferred maintenance for Canada’s entire infrastructure could be several times higher; it could easily exceed five trillion dollars by 2067. The consequences of lack of regular maintenance are accelerated deterioration of any infrastructure asset, requiring much larger expenditures on repair and rehabilitation. However, if neglect of maintenance still persists, the level of deterioration can reach such high levels that it will not be possible to rehabilitate and salvage the system, even at a very high cost

It should be noted that any deterioration in an infrastructure facility is like a cancer in a

human being, which if detected and cured in time can result in a long useful life for the individual. Any neglect or deferred action would normally result in the spread of the cancer, with fatal consequences for the individual. A similar situation prevails for infrastructure facilities.

How soon into the commissioning of a new public infrastructure asset does attention need to turn to a serious maintenance regime ... let us say for a road or bridge for example?

Normally, a new infrastructure facility does not need much maintenance in the early stages of the lifecycle, however, due to wear and tear, and deterioration due to any aggressive environment in the immediate vicinity of the facility, some maintenance would be needed, commencing normally around an age of 5 years. The level of maintenance needed would normally increase with the age of the facility.

What % of an asset’s total cost should optimally be set aside for maintenance?

The maintenance records from facilities around the world show that the maintenance costs in the mid-lifecycle of a facility normally vary between 2 and 4% of its cost, with due consideration for inflation and forecast interest rates. The expenditure on infrastructure maintenance in Canada has generally varied between zero and 2%, with the higher limit being needed at later ages of the facility.⁸

⁷ The service life values for highways, water and wastewater treatment plants, hospitals and recreational centres are not specified in any of the Canadian standards. We obtained these numbers from the international literature.

Do you see a benefit to an asset's lifespan when you bundle design, construction and long-term maintenance in the same contract? What kinds of incentives help improve the process?

Definitely yes. One can see the positive outcome of the recently-constructed large projects, such as the Confederation Bridge between New Brunswick and PEI, Highway 407 in Toronto, and others around the world. These projects were implemented using public-private partnerships and design-build-operate models for long periods of time, after which the facility would be handed over to the government to operate and manage. Regular maintenance operations have kept these systems in excellent condition.

Unfortunately, most of our standards and contracts are based on materials specifications which need to be fulfilled initially by the contractor. This does not guarantee acceptable performance of the facility during the operations phase, which requires excellent quality control during implementation of the project and regular maintenance during the service life of the facility. Instead of focusing on material properties during the construction phase, increased emphasis is needed on quality control during the project implementation phase and regular and preventive maintenance during the operation phase.

We sometimes hear about a "10-year guarantee" on a road construction or perhaps longer on a building. Is discussing infrastructure in these terms helpful to improving the life of assets? Would some kind of certification equivalent to the LEED system be beneficial to the industry in terms of sustainable infrastructure?

The 5 or 10- year guarantees are related to the satisfactory performance of the facility over the stipulated period after the project is completed and handed over to the owner. It would be beneficial to include such performance guarantees in the contracts because such performance over a period of 5 to 10 years can only be achieved through high quality construction implementation, followed by a good maintenance regime. A fraction of the contract amount can be held in trust over this period. A detailed inspection of the facility can be undertaken before the end of this period and any defects or flaws can be repaired at the contractor's expense. Normally, most of the flaws and deterioration damage would be manifested within the first five years of the facility service life.

The LEED system is very popular and helpful in rating the facilities for being sustainable and environmentally friendly. However, to the best of my knowledge, the earlier version of LEED did not include consideration of lifecycle performance and costs. A scheme similar to the one suggested above can be useful (i.e., detailed inspection before the end of five years post-construction along with the repair of any defects and flaws at the contractor's expense).

The current laws in Canada normally do not hold the engineer and the contractor responsible for the facility after a five year period. Some systems, such as roads and bridges, have been observed to deteriorate more rapidly in the middle and the later third of their lifecycles. I recommend that the owner should volunteer to undertake a detailed audit of the current health of the facility at that time and undertake appropriate repair/rehabilitation measures to upgrade the facility. This is similar to the detailed medical tests on advanced age persons, to determine any corrective measures that need to be taken

to ensure a fulfilling remaining life. Such steps could have helped to avoid the tragic situations that were encountered with de la Concorde Overpass collapse in Laval and the collapse of a floor of the underground parking garage in a high rise apartment building in Ville St. Laurent, Quebec. Many such tragedies have occurred in Canada, the United States and around the world; many of these could have been avoided if appropriate integrity audits had been undertaken in the second half of their life-cycle with appropriate remedial measures following the audit.

The federal and provincial governments are currently on a "shovel-ready" funding agenda. Do you see this benefitting Canada's infrastructure in the short or long term? What are the pros and cons of such a large and fast infrastructure program?

Personally, I support the concept of funding for "shovel-ready" projects as they will help with the amelioration of Canada's deteriorated infrastructure. It should be emphasized that "shovel-ready" projects need not be new projects; more emphasis needs to be placed by all levels of government on rehabilitation of Canada's deteriorating infrastructure. If we continue to postpone the required upgrading, the future costs will escalate at a very rapid rate- a situation which must be avoided.

The governments must ensure a reasonable balance between new construction and rehabilitation of existing severely deteriorated assets. The decision should be made depending on the risk faced by the citizens due to lack of timely rehabilitation of the deteriorated facilities.

Technology has changed significantly over the past few decades (e.g. trenchless road repair, improved

R-values, better concretes, etc.). Do you think the policy and funding of infrastructure has followed suit?

I agree that technology, involving construction, non-destructive testing for diagnosis and repair and rehabilitation techniques have progressed significantly over the past two decades. However, government policies and funding have lagged behind quite seriously.

In summary, what are the main issues and what can be done about the infrastructure deficit?

1. The present philosophy of “design, build and forget” for infrastructure must be changed to design, construction and performance (operations, maintenance, repair/rehabilitation,

etc.) over the entire lifecycle of the facility. Maintenance should never be deferred under any circumstances; the owner must make appropriate financial provision for maintenance when seeking funds for the project.

2. I would urge a shift from the current emphasis on material properties to performance-based specifications, covering the performance of the facility over its entire lifecycle.
3. The owners should be encouraged to undertake a detailed audit of the current state of health of the facility, and to take appropriate measures to remedy any observed flaws or damage due to any mode of deterioration

4. The need for a national infrastructure policy for Canada cannot be overemphasized. The Federal Government must assume the lead to find appropriate solutions in consultation with the other levels of government and the various stakeholders.
5. The cost of inaction on our part would be facing drastically higher and more severe levels of deterioration in most of our infrastructure assets. The cost of replacing these assets could easily run into tens of trillion dollars. Who will pay for it? Our grandchildren and their grandchildren will have a very low quality of life because of the heavily deteriorated and in some cases absolutely non-functioning infrastructure.