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# The State of Infrastructure in Canada: Implications for Infrastructure Planning and Policy

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By

**M. Saeed Mirza, Ph.D., ing  
Professor**

**Murtaza Haider, Ph.D.  
Assistant Professor**

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# The State of Infrastructure in Canada: Implications for Infrastructure Planning and Policy

## **1.0 Executive Summary**

Commencing with a review of the findings of the 1985 and 1995/96 surveys, the report focuses on the current infrastructure deficit (\$125 billion) for the entire infrastructure in Canada under the jurisdictions of the federal, provincial, regional and municipal governments and the private sector. The results of the 1995/96 survey are presented summarily and the lesson learnt from this and the previous surveys in light of the peculiarities and other difficulties of Canada's infrastructure are briefly reviewed. The need to develop a National Infrastructure Policy, innovative sources of funding, a Canada Infrastructure Bank and rehabilitation of existing deterioration of infrastructure are emphasised.

The creation of a Network of Centres of Excellence to deal with durability problems of all infrastructure and vulnerability issues of critical infrastructure in Canada is discussed briefly. In addition, a recommendation is made to develop and deliver "academic" courses at colleges, universities and other institutions related to infrastructure and aimed at technicians, and undergraduate and graduate students. It is recommended that professional and learned engineering societies, specialised organisations like CERIU and the Infrastructure Guide develop and deliver related continuing education courses to practising engineers and managers.

Definitive recommendations are made for future surveys to deal with the entire infrastructure in Canada. This internet based survey can develop a data base about the various facilities, their history, present condition and future related activity by the relevant organisation, and which can be updated at regular intervals. The report briefly reviews many of the modalities related to such a survey.

## 2.0 Historical Background

Since the early days of Confederation, the Government of Canada has played a pivotal role in the development of national infrastructure such as, the construction of the coast-to-coast railways and Trans-Canada Highway. Further foresight and investment by all levels of government and the private sector have resulted in our multi-trillion dollar infrastructure. The health and the well being, and the quality of life of all Canadians, depend strongly on basic services such as roads, bridges, sewers, water supply, schools, airports, telecommunication and transit systems, which along with some other services collectively form our infrastructure (FCM,1985). In addition, our national prosperity, international competitiveness, economic growth and, consequently the overall quality of life depend on the efficiency of our productivity, transportation and marketing of our goods and services. The government and the private sector have a tremendous responsibility to maintain the vast infrastructure in a reliable working condition to ensure our sustained economic growth, international competitiveness and the resulting high quality of life.

After the Second World War, there was an urgent need for new infrastructure due to a significant increase in Canada's population. This development of new infrastructure continued into the 1960's due to the "baby boom", significant immigration levels and the increase in urbanisation (CMHC, 1992). The population of Canada grew by 27% during the decade (1970-79), and this growth started diminishing in the late seventies. Consequently, the need for further infrastructure expansion decreased (FCM, 1993), which led to considerably lower expenditures on infrastructure construction, and on maintenance and rehabilitation of existing infrastructure. The trend of moving into new and larger homes in less dense areas and the urban sprawl began absorbing any excess capacity in the existing infrastructure and resulted in a steadily increasing demand for new infrastructure. This further compounded the infrastructure problem due to gradually increasing backlog of maintenance and any needed replacement work(FCM, 1993).

Until the early seventies, Canada's infrastructure was maintained at an acceptable level by all levels of government and also because several of the infrastructure facilities were relatively new, requiring lower maintenance levels. This was followed by a period during which the expenditures on new infrastructure construction, and maintenance and rehabilitation of infrastructure decreased considerably. Several factors contributed to the

constantly growing infrastructure problems, including the pressure on the budgets due to the economic recession, some post-Second World War infrastructure reaching the end of its service life, rapid inflation of the late 1970's, and competing demands for the various infrastructure. These problems were further exacerbated by the reluctance of the authorities to borrow at the high interest rates of the 1980's, increased public involvement in decision making and the reduction in private, municipal, provincial and federal funds for infrastructure development, maintenance and rehabilitation. Many of Canada's infrastructure facilities have already exceeded their normally expected service life. Several of the water supply pipelines in Montreal are well over a hundred years old and it is not uncommon to find sewers in older Canadian cities which are between fifty and seventy-five years old. This escalating deterioration of infrastructure is basically due to deferred maintenance and has already resulted in the failure and closing down of some facilities, such as roads, bridges, and water supply and sewage disposal lines. These service disruptions are becoming a common occurrence. These difficulties have been aggravated further by the aggressive physical environments, the lack of scientific provisions in design codes and practical tools for the design of new durable infrastructure and for maintenance and rehabilitation of existing infrastructure. The overall expenditures on Canada's infrastructure totalled about \$11 billion in the late eighties, however, which was used mostly for new construction, with only 20% of the amount allocated to the rehabilitation of deteriorated infrastructure. This lack of attention by all levels of government has led to the current unacceptable deteriorated state of Canada's infrastructure.

Presently, all of the governments, especially the local ones, are facing an infrastructure crisis of frightening proportions due to several years of deferred maintenance and neglect, requiring costly repair, rehabilitation and replacement. The state of infrastructure around the world has declined steadily at least over the past three decades and several of these existing infrastructure facilities are inadequate to meet the present population requirements and the projected future growth and development. Infrastructure everywhere is in serious need of repair and upgrading. Also, once deterioration sets in, it continues to compound exponentially. Along with the escalating repair costs, it is becoming more difficult and expensive to repair and rehabilitate these facilities. In 1989, a Joint Committee of the U.S. Congress estimated that the cost of repairing the U.S. infrastructure over the following 15 years was about U.S. \$1 trillion (Matzer, 1989). Also, the U.S. Department of transportation stated that by the mid-1990's, deteriorating infrastructure would cost American society almost 6% in disposable income, 2% in employment growth and nearly 3% in manufacturing productivity (Portland Cement Association, 1992).

In 1983, the Federation of Canadian Municipalities (FCM) created a Task Force and a Technical Committee on Municipal Infrastructure. Based on the responses to a questionnaire by members and selected non-members, the FCM published a report in January 1985, entitled: "Municipal Infrastructure in Canada: Physical Condition and Funding Adequacy". The study concluded that some essential services, such as roads, bridges, sidewalks and sewer systems were in poor condition, or were deteriorating, while community and social services such as parks, community centres and libraries were in a relatively good condition. As expected, the relatively young water treatment and sewage facilities were found to be in good shape. The price tag to upgrade the municipal infrastructure facilities was estimated at \$12 billion (FCM, 1985), and this cost mushroomed to \$20 billion in 1992 (FCM, 1992). The response of the participants at the 1992 FCM Annual Conference to a "green card" questionnaire showed that renewal priorities had shifted from roads, bridges and sidewalks to sewers (FCM, 1992), showing that infrastructure priorities can change over a period of time.

Comparison of the above results with the results of a similar study undertaken by the National League of Cities and the United States Conference of Mayors in early 1985 showed that Canada's infrastructure was generally in a better condition than their American counterparts (FCM, 1985). Moreover, the same facilities such as roads, bridges, sidewalks, storm and sanitary sewers were judged to be in the poorest condition in both countries. A National Council on Public Works Improvement studied categories of U.S. infrastructure, representing about 10% of the total stock, and emphasised that the public works were a major source of employment in construction, operation and maintenance of infrastructure, and to keep America competitive, capital spending on infrastructure needed to be increased by 100% (Matzer, 1989). The annual public spending on these facilities exceeded US\$100 billion which was about 7% of all government spending. The Council noted that the quality of America's infrastructure was barely adequate to fulfil the present requirements, and insufficient to meet the demands of any future economic growth and development. Most of the major US infrastructure categories were operating at only a passable level; a few facilities, such as water supply and water resources were in a reasonably good shape, while others such as solid waste and hazardous waste disposal had serious growth problems (National Council on Public Works Improvement, 1988). The results of the eight infrastructure categories were presented summarily.

Over the years, the European authorities have managed their infrastructure quite well, and generally, the European infrastructure conditions are better than the Canadian ones. In most European countries, federal or central government funding is available for local

infrastructure maintenance. Since some of these countries are involved in profitable banking and mining enterprises, plenty of revenues are available to offset the cost of some local services. A recent Australian survey determined that infrastructure costs comprise about 15% of the operating costs of their multinational corporations and other industrial organisations. It is, therefore, appropriate that these large private sector corporations contribute in maintaining the infrastructure which has been instrumental in making large annual profits. While properly functioning and good infrastructure is essential to attract these corporations and industries, these organisations have at least a moral responsibility to enable all levels of governments to maintain this critical infrastructure. As of the mid-nineties, there were no organised national infrastructure surveys in Europe and any information retrieval systems used were not as advanced. However, the Europeans were in the process of establishing service standards for infrastructure management systems, which had not been undertaken in North America until the mid-nineties.

The World Economic Forum/ Institute for Management and Development(WEF/IMD) ranked the relative positions of Canada's infrastructure among the 22 developed countries using the broad definition of infrastructure as " the extent to which resources and systems are adequate to serve the basic needs of business" (NRC, 1993). Canada was ranked 5th overall behind Norway, Switzerland, Sweden and Denmark. Canada ranked 5th in air transport, 7th in railroads, 8th in road transport, 11th in water treatment and 15th in municipal waste per capita.

The infrastructure investment needs in the former Soviet Union were assessed at US\$4.0 trillion, US\$2.5 trillion in Asia, excluding Japan, US\$5.3 trillion in Japan, US\$1.9 trillion in former East Germany and US\$1.0 trillion in the United States. In summary, the condition of infrastructure is better in Canada than in the US, however, it is not as good as in Europe. The revenue shortfall is more severe in Europe than in the U.S. The data shows that Canadian municipalities receive much less assistance on per capita basis than the American municipalities and considerably less than the European municipalities. Moreover, the U.S. infrastructure authorities and politicians at all levels of government, including the President of the U.S. recognised the infrastructure crisis earlier than Canada and began to resolve their problems and ameliorate their infrastructure immediately (FCM, 1985).

The infrastructure deficiencies are abundantly evident in our city roads, water supply and sewage disposal systems. Large quantities of drinking water, in some instances almost 50%, are being lost in some communities because of severely deteriorating water mains.

Also, any infiltration of aggressive agents (as was the case with Walkerton and some other communities) has the potential of causing serious health hazards at tremendous cost to the tax payers. Since well-functioning infrastructure impacts Canada's productivity, national economy, international competitiveness and the overall quality of life, it is extremely important for all levels of government and the private sector to adopt infrastructure as a very important fiscal responsibility at par with health, education, and other sectors. All of the above clearly points out to the urgent need to develop a National Infrastructure Policy. To provide a framework for the development of new strategically targeted infrastructure, and maintenance and rehabilitation of the existing infrastructure, this policy must encourage innovative funding resources. An earlier suggestion made by the authors was to create a Canada Infrastructure Bank, based on the success of the various state infrastructure banks in the United States. More details can be found in the paper by Mirza and Amleh (2002).

## **2.1 Technical Issues**

Many of the problems mentioned earlier have arisen because of the present on-going practice of designing and building systems without explicit consideration of their performance over their entire service life, and normally, without any consideration of specific provisions for maintenance of the infrastructure systems, as compared with similar programs in aircraft, automobile, nuclear and other industries. Proper management of the infrastructure must deal with every facet of infrastructure life, including conception, feasibility studies, design, construction, operation, maintenance, repair and rehabilitation, and finally, decommissioning and disposal of the system after it has served and outlived its useful life. Every step of these life-cycle performance considerations must be moderated by the socio-economic and environmental concerns in Canada and therefore, these activities should be guided by the principles of sustainable development.

## **2.2 Infrastructure Deficit**

The 1995 McGill-FCM (Federation of Canadian Municipalities) survey of Canada's municipal infrastructure estimated that it would require \$44 billion to bring it up to an acceptable level. When the cost of rehabilitation of the infrastructure under the provincial and federal jurisdictions and the private sector are added, the total infrastructure deficit for Canada would far exceed \$100 billion. This estimate is slightly less than one-tenth of the 1998 estimate of the infrastructure renewal needs in the US by the American Society of Civil Engineers (ASCE) of US\$1.3 trillion, and the 1992 Infrastructure Review estimate of

US\$1.0 trillion. Therefore, the estimated cost of Canada's infrastructure is quite realistic by comparison. Moreover, the American infrastructure received a failing grade D, which fell from Grade C in 1988, in the 1998 ASCE Report Card due to continuing deterioration and lack of maintenance, repair and rehabilitation. Canadian highways, city roads, water supply and sewage disposal and other systems are in an equally bad condition. Because of deferred maintenance over nearly three decades, the infrastructure has continued to deteriorate. If the deterioration is not halted, it will escalate exponentially. Furthermore, the uncertainty in the exchange rate, interest rate and future inflation levels, and increasing cost of labour and materials may increase this deficit to about \$200 to \$300 billion over the next 20 to 25 years.

### **2.3 Where do we go from here?**

As mentioned earlier, the various levels of government need to deal with the several infrastructure issues confronting our society. These include principally the scientific management of infrastructure, and finding innovative sources of funding for maintenance, repair and rehabilitation of the existing deteriorated infrastructure. The private sector must be urged to participate in infrastructure renovation because they receive significant benefits from properly functioning infrastructure, which is one of the reasons for the large profits earned by large corporations and multinational organisations. In fact, as mentioned earlier, a recent Australian study showed that the infrastructure costs constitute about 15 percent of the operating expenses of these organisations. With suitable incentives, such as payment of interests at current rates, these corporations can be persuaded to participate in establishing a Canada Infrastructure Bank, which can provide low-interest or no-interest loans to appropriate and deserving infrastructure projects.

### **2.4 Objectives of the Report**

To achieve the above goals, it is essential to develop a detailed state of the art report to deal with the recent technological developments related to all types of infrastructure to enable practising engineers, municipal authorities and others to comprehend all available technologies and to be able to make informed decisions about the case of the various technologies in their projects. This state-of-the-art report must also review the recent trends in management and financing of the infrastructure. This goal can be attained through a detailed review of all available national and international literature. These reports should respond to the important questions posed in your document: "Preliminary Themes and Questions for Policy Research." These reports can then be expanded in terms of their

scope and content to become useful state-of-the-art reports for engineers, municipal and other government and private sector officials in managing their infrastructure using the latest available tools. The objective of the present exercise are to prepare a report on the lessons learnt from the 1995 Municipal Infrastructure Survey undertaken by McGill University in conjunction with the Federation of the Canadian Municipalities. The report will also highlight all of the basic needs for all of Canada's infrastructure under the jurisdiction of the federal, provincial and municipal governments and will make summary suggestions for any future infrastructure surveys.

## 3.0 State of Infrastructure – 1995/96 Survey

### 3.1 Survey Background

The 1995/96 McGill-FCM survey was initially undertaken as a final year undergraduate project in the Department of Civil Engineering and Applied Mechanics at McGill University.

This survey had the specific goals to:

- Update the information available on the status of Canadian municipal infrastructure in 1995
- Compare the state of the municipal infrastructure with that established in the FCM 1985 report also based on a survey<sup>1</sup>
- Study the success of the Federal \$6 billion program

The survey questionnaire was formulated and finalised in consultation with the Technical Committee of the Federation of Canadian Municipalities. The different types of infrastructure that were investigated included the following:

- Bridges
- Roads
- Sidewalks and curbs
- Transit
- Water distribution and supply
- Sewage treatment
- Sanitary and combined sewerage system
- Storm sewers
- Solid waste disposal and resource recovery facilities
- Hazardous waste disposal facility and resource recovery facilities

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<sup>1</sup> In 1983, the Federation of Canadian Municipalities (FCM) created a Task Force and a technical Committee on Municipal Infrastructure. A questionnaire was sent out to all FCM members and selected non-members to examine the state of the infrastructure. In January, 1985, the FCM published the results in a report entitled « Municipal Infrastructure in Canada : Physical Condition and Funding Adequacy ».

- Public buildings
- Community social services (libraries and daycares) and
- Parks and recreational facilities

The survey responses were used to compare the state of the municipal infrastructure of the 1995/96 McGill-FCM survey with its condition in 1985. The survey provided mostly qualitative results although some quantitative information was available. Some of the information was partially useful to some municipalities in establishing their priorities for infrastructure renewal. The most important impediments to successful rehabilitation and maintenance of infrastructure were identified. The average age of the various infrastructure systems, the sources of revenue for operation, replacement and rehabilitation and the estimated investment required to ameliorate the existing infrastructure to an acceptable level were identified. An assessment of the success of the Federal \$6 billion Infrastructure Works program was conducted. Short-term and long-term needs of the municipalities and other organisations in the area of infrastructure were identified. Another goal of this survey was to inform the different levels of government of the extent of the infrastructure crisis and recommend actions necessary for maintaining a healthy economy and the overall quality of life in Canada (McGill-FCM, 1995).

### **3.2 Survey Methodology**

For the purpose of obtaining data and reporting, the municipalities were divided into the following four population groups:

- Group 1:           Population below 10,000
- Group 2:           Population between 10,000 and 100,000
- Group 3:           Population between 100,000 and 400,000
- Group 4:           Population above 400,000

The survey methodology is described in detail in Chapter 5 of the “Canadian Municipal Infrastructure Survey” project report by Siddiqui and Al-Haroun (1995).

### 3.3 Survey Results

#### 3.3.1 Impediments to Successful Rehabilitation and Replacement of Infrastructure

Canadian infrastructure systems have suffered severely from the reduction in the federal and the provincial financial resources. "Funding shortages" was identified by 92% of the respondents as the greatest impediment to successful rehabilitation and maintenance of the infrastructure. Table 3.1 summarises the responses of the municipalities in ranking the six impediments in the survey responses: funding shortages, political inaction, prolonged public involvement, red tape, environmental assessment and lack of staff. The impediments are ranked from 1 to 6, from the most important to the least important.

Table 3.1 Impediments for all responding municipalities (McGill-FCM, 1995)

Impediment	1	2	3	4	5	6
Funding Shortage	92%	7%	0%	1%	0%	0%
Political Inaction	5%	25%	21%	14%	15%	20%
Prolonged Public Involvement	1%	7%	21%	18%	22%	30%
Red Tape	3%	13%	21%	26%	20%	17%
Environmental Assessment	1%	4%	31%	9%	34%	21%
Lack of Staff	8%	24%	17%	10%	13%	28%

A breakdown of the responses for the various population groups revealed that funding shortages ranked as the highest impediment amongst all groups. In general, lack of staff was the second greatest impediment. This was true for Group 2 and Group 3. For Group 1 and Group 4, political inaction and red tape were ranked second, respectively.

### **3.3.2 Sources of Revenue for Operation, and Rehabilitation and Replacement of Infrastructure**

The sources of revenue for operating the different infrastructure facilities are shown in Table 3.2. A major part of the revenue was provided by the municipal general taxes. General tax revenues provide over 50% of the cost of operation for roads, hazard waste and storm sewers, and over 60% for public buildings, bridges, curbs and sidewalks. Over 60% of the sources of revenue for the operation of water supply and distribution is provided by user fees and over 39% for sanitary and combined sewers, sewage treatment and solid waste treatment. The sources of revenue for rehabilitation and maintenance of the different infrastructure facilities are shown in Table 3.3. The general taxes provide the second highest source of revenue for rehabilitation and maintenance in general. Reserves are sources of funds set aside by municipalities for any future use in the operation of municipal activities. The reserves provide over 10% of the funds for the operation of solid waste treatment and disposal, and public buildings. For rehabilitation and maintenance purposes, they provide over 19% of the funds for water distribution and supply. Public-private partnerships constitute over 14% of the funds for parks and recreational facilities for operation and over 12% for rehabilitation and replacement. In general, it is one of the lowest sources of revenue for operation, rehabilitation and maintenance of infrastructure. Debt financing/borrowing is also one of the lowest sources of revenue for operation but one of the highest for maintenance and replacement of infrastructure.

Table 3.2 Sources of Revenue for Operation of Infrastructure Facilities (%) (McGill-FCM, 1995)

Facility	Gen. tax rev	User fees	Reserves	PPP	Debt financing/borrowing	Prov. subsidy	Fed subsidy
Bridges	66.2	0.5	0.1	0.0	2.9	30.1	0.3
Community & social services	39.2	25.0	5.6	4.3	1.4	23.6	0.8
Curbs	67.8	0.9	0.9	0.1	2.2	27.9	0.2
Hazardous waste	55.7	34.1	6.0	0.4	0.5	3.3	0.0
Parks and recreational facilities	35.6	31.1	7.7	14.0	2.8	6.5	2.2
Public buildings	69.2	13.4	11.2	0.4	5.0	0.5	0.3
Roads	58.1	1.1	3.3	0.1	4.2	32.8	0.4
Sanitary and combined system	27.2	39.6	9.2	0.1	11.0	9.7	3.2
Sewage treatment	25.8	43.5	9.2	2.8	14.2	4.5	0.0
Sidewalks	81.8	1.9	1.4	0.2	4.6	9.7	0.4
Solid waste	32.8	40.3	16.4	6.3	1.8	2.2	0.0
Storm sewers	52.6	12.6	7.8	0.4	8.8	17.4	0.4
Transit	36.1	32.0	0.0	3.2	3.0	25.6	0.1
Water distribution	9.7	63.0	9.5	0.1	10.8	3.7	3.2
Water supply	12.0	63.6	9.1	3.2	10.8	1.2	0.1

Table 3.3 Sources of Revenue for Rehabilitation and Maintenance of Infrastructure Facilities (%) (McGill-FCM, 1995)

Facility	Gen.tax rev	User fees	Reserves	PPP	Debt financing/borrowing	Prov. subsidy	Fed subsidy
Bridges	27.4	0.0	7.6	2.3	27.6	28.9	6.1
Community & social services	25.0	5.1	15.6	7.8	25.0	17.7	3.7
Curbs	33.7	1.4	6.5	6.1	24.3	22.9	5.1
Hazardous waste	31.3	28.1	5.4	1.1	23.5	7.4	3.3
Parks & recreational facilities	24.1	4.6	15.5	12.7	18.9	13.9	10.3
Public buildings	29.9	2.8	16.6	6.8	35.1	5.7	3.0
Roads	26.8	1.0	7.3	4.0	24.2	28.6	8.1
Sanitary & combined system	14.4	21.1	18.7	1.7	26.7	13.4	4.0
Sewage treatment	9.1	18.8	18.8	0.0	29.3	14.5	9.5
Sidewalks	36.0	1.1	7.8	8.4	26.1	14.2	6.4
Solid waste	20.2	25.4	17.1	2.0	30.7	4.4	0.1
Storm sewers	26.7	14.9	7.2	3.9	26.7	17.5	3.1
Transit	24.2	20.2	4.9	3.5	25.2	21.8	0.3
Water distribution	4.3	33.1	19.0	1.8	27.3	9.1	5.5
Water supply	3.2	31.2	21.7	1.7	31.9	7.4	2.9

### **3.3.3 Transportation**

#### **3.3.3.1 Roads**

According to the 1996 annual report of Transportation Canada, in 1993, the road capital stock was valued at roughly \$79.8 billion. The 1995-96 McGill-FCM survey concluded that 88% of roads needed some repair, or that their condition was deemed unacceptable. Table 3.4 demonstrates how little this value differed for the different population groups surveyed.

Table 3.4 Condition of Roads in 1995

	Good/Acceptable	Needs some repair/Not acceptable
All Groups	12%	88%
Group 1	20%	80%
Group 2	13%	87%
Group 3	0%	100%
Group 4	17%	83%

The average age of roads was estimated to be 29 years. It was determined that the road network was deteriorating considerably and that the investment needed to upgrade the roads to an acceptable level at the time of the survey was \$8.6 billion.

#### **3.3.3.2 Sidewalks and Curbs**

According to the National Research Council Canada (NRC), the length of sidewalks in Canada is estimated at 100 000 km. Over 70% of the sidewalks and curbs were assessed as being in an unacceptable condition requiring some repair. It was also found that in over 35% of the municipalities, these sidewalks and curbs were deteriorating considerably. Tables 3.5 and 3.6 summarise the state of the sidewalks for the different population groups surveyed.

Table 3.5 Condition of Sidewalks in 1995

	Good/Acceptable	Needs some repair/Not acceptable
All Groups	26%	74%
Group 1	25%	75%
Group 2	19%	81%
Group 3	16%	84%
Group 4	35%	65%

Table 3.6 Condition of Curbs in 1995

	Good/Acceptable	Needs some repair/Not acceptable
All Groups	29%	71%
Group 1	33%	67%
Group 2	20%	80%
Group 3	28%	72%
Group 4	32%	68%

The average age of the sidewalks was estimated to be 27 years. In rural areas (Group 1), the average age was the lowest (19 years) and in urban areas (Group 3 and Group 4), it was the highest (32 years and 28 years, respectively). The average age of the curbs was estimated to be 25 years. Once again, this value was lower in rural areas than in urban centres (Group 1: 20 years, Group 2: 22 years, Group 3: 28 years and Group 4: 39 years).

The cost of upgrading the sidewalks and curbs to a satisfactory level was estimated to \$1.4 billion and \$0.6 billion, respectively. The replacement of the sidewalks would have required an investment of \$12 billion.

### 3.3.3.3 Bridges and Overpasses

According to the McGill-FCM survey, the rehabilitation needs for the bridges in Canada are about \$0.7 billion annually. The report also concluded that the condition of 19.7% of bridges improved, while the condition deteriorated considerably for another 39.5% bridges between 1985 and the 1995 surveys. It can be observed from Table 3.7 that at a national level, 83 % of all bridges need some sort of repair. The average age of a bridge is estimated to be 32 years. This value does not vary significantly amongst the four population groups surveyed. Also, this value compares very unfavourably with the 75-year service life specified in the current Canadian bridge design code.

Table 3.7 Condition of Bridges in 1995

	Good/Acceptable	Needs some repair/Not acceptable
All Groups	17%	83%
Group 1	64%	36%
Group 2	33%	67%
Group 3	11%	89%
Group 4	16%	84%

### 3.3.3.4 Transit

The transit system was noted to be deteriorating at the national level. Systems in larger metropolitan areas are ageing, deteriorating and undercapitalised, while the transit systems in smaller metropolitan areas are underused and overcapitalised. This is reflected by the fact that 40% of the respondents in less densely populated areas (Groups 1 and 2) stated that their transit system was deteriorating compared to over 60% for the more densely populated areas (Groups 3 and 4). At the national level, an estimated 67% of the transit system required some repair, and in fact, upgrading it to an acceptable level would have necessitated an investment of \$3 billion. The needs for rehabilitation of the transit system are more important for the larger population groups (Groups 3 and 4). Table 3.8 illustrates this point.

Table 3.8 Condition of Transit in 1995

	Good/Acceptable	Needs some repair/Not acceptable
All Groups	33%	67%
Group 1	84%	16%
Group 2	72%	28%
Group 3	45%	55%
Group 4	24%	76%

### 3.3.4 Water Distribution and Water Supply

If transportation is the most visible part of our public works, then water supply and distribution systems are the undercurrent. The survey established that 59% of the water distribution networks and 43% of the water supply systems were in unsatisfactory condition in 1995. The average age of the water distribution network and the water supply system were determined as 37 years and 36 years, respectively. Breaks and leaks plague the water mains in older cities, which should not come as a surprise, especially when realising that over 50% of water distribution networks are noted to not perform satisfactorily (Tables 3.9 and 3.10) .

Table 3.9 Condition of Water Distribution in 1995

	Good/Acceptable	Needs some repair/Not acceptable
All Groups	41%	59%
Group 1	46%	54%
Group 2	29%	71%
Group 3	37%	63%
Group 4	44%	56%

Table 3.10 Condition of Water Supply in 1995

	Good/Acceptable	Needs some repair/Not acceptable
All Groups	57%	43%
Group 1	59%	41%
Group 2	63%	37%
Group 3	72%	28%
Group 4	52%	48%

To bring the water distribution and water supply systems to acceptable levels of performance at the national level, expenditures of \$6.1 billion and \$3.1 billion dollars, respectively, are necessary.

### **3.3.5 Sewage Treatment, Storm Sewers and Sanitary and Combined Sewers**

While wastewater treatment plants and sewers or conveyance systems lack public concern, they make up for in utility and public health provision. It is alarming to find that 68% of sanitary and combined sewers, 58% of sewage treatment systems and 53% of storm sewers did not operate at an acceptable level; they needed some type of repair. A breakdown of the responses in Tables 3.11, 3.12 and 3.13 for the various population groups revealed that wastewater treatment and conveyance crises have emerged in communities of all sizes throughout Canada.

Table 3.11 Condition of Sanitary & Combined Sewers in 1995

	Good/Acceptable	Needs some repair/Not acceptable
All Groups	32%	68%
Group 1	40%	60%
Group 2	25%	75%
Group 3	25%	75%
Group 4	35%	65%

Table 3.12 Condition of Sewage Treatment in 1995

	Good/Acceptable	Needs some repair/Not acceptable
All Groups	42%	58%
Group 1	51%	49%
Group 2	44%	56%
Group 3	72%	28%
Group 4	36%	64%

Table 3.13 Condition of Storm Sewers in 1995

	Good/Acceptable	Needs some repair/Not acceptable
All Groups	47%	53%
Group 1	49%	51%
Group 2	35%	65%
Group 3	5%	95%
Group 4	62%	38%

With an estimated average age of 42 years in 1995, the sanitary and combined sewers are noted to be the oldest type of infrastructure in this survey. Storm systems and sewage treatment plants were estimated to have an average life of 32 years and 24 years, respectively. With an estimated 109 296 km of pipe, the replacement cost of this ageing system without taking into account pumping stations and treatment plants was estimated at \$86 billion. According to the 1995/96 McGill-FCM survey, upgrading the sanitary and combined sewers, the sewage treatment plants and storm sewers was estimated at \$4.3 billion, \$4.5 billion and \$3.0 billions, respectively.

### **3.3.6 Hazardous Waste and Solid Waste**

The collection, transportation and treatment/disposal of hazardous waste and solid waste is of serious environmental concern. Although the McGill-FCM survey seems to indicate that the condition of these systems had remained stable over the period of comparison between 1985 and 1995, an estimated 55% of solid waste plants were deemed unacceptable. At the national level, only 3% of hazardous waste plants required some

repair. This number is misleading since the results, when broken down amongst the various population groups, revealed that 68% of the respondents in the municipalities with populations under 10 000 (Group 1) ranked the condition of their hazardous waste plant as poor or unacceptable (Tables 3.14 and 3.15).

Table 3.14 Condition of Solid Waste in 1995

	Good/Acceptable	Needs some repair/Not acceptable
All Groups	45%	55%
Group 1	46%	54%
Group 2	53%	47%
Group 3	76%	24%
Group 4	38%	62%

Table 3.15 Condition of Hazardous Waste in 1995

	Good/Acceptable	Needs some repair/Not acceptable
All Groups	97%	3%
Group 1	32%	68%
Group 2	77%	23%
Group 3	100%	0%
Group 4	100%	0%

With an estimated average life of about four years in 1995, the hazardous waste plants are the youngest type of infrastructure. The average life of solid waste plants was estimated to be about 15 years. To update the solid waste plants and hazardous waste plants, it was estimated that \$0.8 billion and \$0.2 billion needed to be invested respectively. The response rates for these cost estimates were only 24% and 14 %, respectively. These results need to be interpreted carefully.

### 3.3.7 Community and Social Services

Although community and social services have remained at the same level in general, an astounding 67% of these services were not acceptable. In general, these services seemed to be performing better in smaller municipalities than in larger ones (Table 3.16).

Table 3.16 Condition of Community and Social Services in 1995

	Good/Acceptable	Needs some repair/Not acceptable
All Groups	33%	67%
Group 1	72%	28%
Group 2	75%	25%
Group 3	40%	60%
Group 4	16%	84%

### 3.3.8 Public Buildings

In general, 60% of public buildings were not performing well. This value reflects the situation of most population groups accurately enough as it can be observed from Table 3.17. An estimated \$4.0 billion was deemed necessary to upgrade these buildings to an acceptable level.

Table 3.17 Condition of Public Buildings in 1995

	Good/Acceptable	Needs some repair/Not acceptable
All Groups	40%	60%
Group 1	47%	63%
Group 2	42%	58%
Group 3	34%	66%
Group 4	42%	58%

### 3.3.9 Parks and Recreational Facilities

At the national level, only parks and recreational facilities have improved over the period between 1985 and 1995. 44% of these facilities require some repair and an estimated \$1.7 billion was necessary to upgrade these facilities to an acceptable level. It is worthwhile noting from Table 3.18 that for Group 3, 82% of these facilities did not perform satisfactorily.

Table 3.18 Condition of Parks and Recreational Facilities in 1995

	Good/Acceptable	Needs some repair/Not acceptable
All Groups	56%	44%
Group 1	57%	43%
Group 2	48%	52%
Group 3	18%	82%
Group 4	66%	34%

### 3.4 Survey Conclusions

The analysis of the results of the survey were summarised as follows:

- a. The survey was considered successful due to its high response rate of 28%, representing approximately 55% of the total Canadian population.
- b. Funding shortages are the greatest impediment to successful maintenance and rehabilitation of infrastructure.
- c. General tax revenues and user fees are the most often used source of funding for operating the infrastructure facilities, while debt financing and borrowing are used to pay for rehabilitation and replacement of the facilities.
- d. At the national level, transit, roads and curbs had deteriorated the most over the 10 years between 1985 and 1995.
- e. At the national level, roads, bridges and sidewalks were in the greatest need for repair.
- f. Sanitary and combined sewerage systems, water distribution, and water supply, were among the oldest infrastructure facilities in Canada.
- g. The total per capita cost required to upgrade the infrastructure facilities surveyed, based on the responding population, was \$1484/capita, giving a total cost of \$24

billion for the responding municipalities, and an estimated total cost of \$44 billion for all of the municipal infrastructure in Canada.

- h. Where user pay funding supported infrastructure development and maintenance, these systems seemed to perform more satisfactorily than those supported through general revenue funding.
- i. The \$6 billion Federal Program was considered successful in improving the state of the municipal infrastructure and for a majority of respondents, it was found to have funded the most important programs in their community (McGill-FCM, 1995).

## **4.0 Emerging Challenges for Infrastructure Provision and Management**

In this section we present some of the challenges facing infrastructure provision and management in Canada due to her peculiar economic and demographic attributes.

### **4.1 Ageing Population and Infrastructure**

The Canadian population is fast ageing. The 2001 Census has shown the biggest census-to-census increase in the median age of Canadians in a century. The median age of Canadians reported in the 2001 Census touched an all time high of 37.6 years.

The fastest growing segment of the Canadian population is aged 80 and over. During 1991-2001, their numbers increased by 41.2% to 932,000. Their numbers will further increase by another 43% during the next 10 years by-passing the estimated number of 1.3 millions.

At the same time, the Census has shown a decline in the percentage of younger cohorts. The number of children aged four and under has declined significantly in the past decades. From 1966 to 200, the population of Canada increased by 50% from 20 million to 30 million. The same period witnessed an 8% decline in the population aged 19 and under.

These demographic trends will have serious impacts on infrastructure provision in Canada. As baby boomers are ageing and heading to the retirement, so is the infrastructure they constructed. The ageing infrastructure needs repairs and in many instances, needs replacement. On the other hand, the ageing of the population dictates the type of infrastructure being replaced. The special needs of an ageing populace will have serious impact on the design of new infrastructure in Canada. For example, the distance between transit stops, types of transit, health care facilities, etc. Therefore, Canada does not only have to replace and add new infrastructure, but also the design and nature of the new infrastructure should correspond to the realities of changing demographics in Canada.

### **4.2 Infrastructure Provision and Economic Productivity Pressures**

It is critical that large urban centres should be paid greater attention for their role in the economic well being of Canada. Two-thirds of Canada's population, employment, and real output are located in 27 Census Metropolitan Areas (CMAs). The Greater Toronto

Area (GTA), for example, enjoys a pivotal position in Canada. The GTA, being the largest housing market in Canada, represents 55% of new home sales in Ontario and 25% of new home sales in Canada. The State of California, in comparison, is responsible for only 10% of total new US housing sales. The GTA is one of the fastest growing regions in North America. The Canada Mortgage and Housing Corporation (CMHC) has reported over 41,000 housing starts in the GTA in 2001. Statistics Canada's Labour Force Surveys reveal that almost 6% of Ontario's 6 million workers are employed in the construction industry. In addition, Ontario is home to 40% of the 850,000 Canadian workers employed in the construction industry. Significant enhancements are needed for the infrastructure in the GTA for sustained economic growth.

Major metropolitan areas in Canada often produce half of the provincial GDP, resulting from the strong concentration of production processes and the service industries in large urban centres. Table 4.1 presents the percentage of the provincial GDP accounted for by the large urban centres. Thus the provision of new infrastructure and the rehabilitation of the existing infrastructure has a direct bearing on the productivity and competitiveness of Canada.

Table 4.1: Percentage of the provincial GDP accounted for by the cities

City	Province	% of GDP
Montreal	Quebec	50
Toronto	Ontario	44
Vancouver	British Columbia	53
Calgary & Edmonton	Alberta	64
Winnipeg	Manitoba	64
Halifax	Nova Scotia	48

Source: Conference Board of Canada cited in TD Economics (2002)

### 4.3 Sub-urbanisation and the Cost of Infrastructure Provision

Urbanisation and the subsequent sub-urbanisation of Canada will determine the nature and extent of current and future infrastructure needs in Canada. Recent figures indicate that urbanisation in Canada has continued at a steadfast pace, which calls for an urban focus for infrastructure provision in Canada. The three largest Canadian cities—Toronto,

Montreal, and Vancouver—are home to one-third of the national population. Urban form plays a significant role in infrastructure provision; well-managed, sustainable growth results in a lower demand for infrastructure, while urban sprawl encourages auto-dependency and greater number of long-distance trips, requiring extensive additions to transportation and other infrastructure.

Urban sprawl or land-intensive developments increase the cost of infrastructure provision. For example, studies have discovered that land-intensive development patterns require more lane kilometres, requiring higher capital investments (Burchell (1992), Frank, 1989). Burcher et al (1998) discovered that construction costs of local roads under compact growth patterns were 30% lower than the road network needed for a land-intensive type development. Similarly, maintenance costs for compact growth were found to be lower than land-intensive development patterns (Burcher (1992), Esseks et al (1999).

Other infrastructure provision costs such as water and sewer services are also impacted by the urban form. Earlier studies have demonstrated that the centralised water and sewer services costs depend upon the spatial form of development (Burcher et al. (1998), Frank (1989), Downing and Gusteley (1977), and Wheaton and Schussheim (1995)). Lower density developments often result in longer length of pipes required to offer such services. A Canadian study discovered that low-density developments in the Greater Toronto Area would cost billions more than re-urbanisation or brown-field developments (Blais et al. (1995).

Smart Growth initiatives are recognised as one approach to integrated transportation-land use planning. Smart Growth refers to a planning concept that maximises the use of existing infrastructure and resources by creating compact urban forms characterised by mixed land uses, relatively high densities, and employment nodes. Smart Growth initiatives do not, however, offer solutions to the already-existing sprawl. One approach is to develop residential neighbourhoods on brown-field sites as a means to redirect growth inwards. Such development patterns put less pressure on the demand for new infrastructure. With inward growth, the existing infrastructure could be used. There is, therefore, a need to develop formal models of urban evolution to test the validity of the hypotheses behind potential solutions such as Smart Growth.

The 2001 Census reveals the rapid increase in the sub-urbanisation of residences and employment. More and more businesses are locating in the suburbs to benefit from the low commercial taxes, cheaper land values, etc. These trends will continue for some time, putting severe pressure on the infrastructure, which has to be extended further out to accommodate the sprawl.

Canada, as a signatory to the Kyoto Protocol, has international commitments to uphold regarding the environment and climate change. The transportation sector is a major source of greenhouse gas emissions. If the current trends in travel behaviour (an outcome, in part, of the urban sprawl) and the subsequent construction of new infrastructure continue, Canada may not be able to honour its commitments vis-à-vis the Kyoto protocol.

As for the transportation infrastructure, the very type of infrastructure that is enhanced will determine the equity dimensions of mobility. Issues of accessibility remain at the heart of transportation systems. Low-income households may not enjoy the same access to activities and opportunities due to constraints such as location, disability, and poverty. Public transit can help bridge the gap between those who can afford access to work and leisure opportunities, and those who lack the resources to pursue their own choices. The urban transit infrastructure in Canada still possesses a central (downtown) focus, which offers competitive travel times for trips around the Central Business District (CBD) and along the high-speed transit lines. However, transit service can not effectively compete with the automobile for trips that originate or end in the inner and outer suburbs.

It is critical to understand that the construction of new infrastructure may not always be the best long-term solution. Often, a conservationist approach, with the focus on curbing demand or making the best use of the existing infrastructure, may offer the sustainable solution. For the case in point, one cannot simply add capacity to the transportation infrastructure in the hope of achieving a sustainable solution. As additional capacity is provided in the road network, more vehicles will be brought on the roads to use the additional capacity. An incremental approach in enhancing transportation infrastructure could be made using a three-tier strategy. The first tier involves the introduction of IT-based infrastructure to relieve congestion, e.g., Intelligent Transportation Systems and/or the reengineering of bottlenecks. Short- to mid-term planning would require growth management. Long-term planning would require that consumer behaviour and expectations change, so that compact urban form becomes a popular housing option. The future of efficient transportation systems is thus tied to a socially desirable (compact) urban form, which can be achieved by developing a better understanding of the provision of new housing.

#### **4.4 Challenges in Infrastructure Finance**

In urban Canada, major investments in the transportation infrastructure were made in the 1950's and 60's. Over the past couple of decades, large Canadian cities have enjoyed a good reputation among North American cities for their quality of life, owing in part to the

investments made earlier. However, the urban infrastructure is now crumbling and is in major need of rehabilitation and replacement. The costs to rehabilitate the infrastructure in urban Canada run into billions of dollars. There is, however, no agreement on how to finance these inevitable costs.

Municipal governments in Canada are not allowed to generate revenue (by imposing taxes) or to finance projects with debt (by issuing bonds and debentures). This has corresponded with the relatively slow revenue growth of municipalities, when compared with the revenue growth experienced by the provincial and federal governments. For instance, between 1995 and 2001, local government revenues increased by 14% only when compared with 38% increase in the federal revenues and 30% increase in the provincial revenues (TD Economics, 2002). The result has been a heavy reliance on property taxes by the local government, which is not an appropriate source of revenue for long-term funding needs.

Municipalities in the United States enjoy greater freedom in raising revenue through direct taxation. In addition, municipalities in the US also draw revenue from “cyclically-sensitive revenue sources – such as sales tax and user fees.” Some local governments such as New York also levy income tax.

Urban sprawl or low-density developments in the suburbs or ex-burbs pose significant challenges for the vitality of Canadian cities. The outward movement from the city centres by both households and businesses shrinks the tax-base, forcing the central municipalities to charge higher property taxes, which ends up increasing the outward movement out of the central municipalities. Table 4.2 presents a breakdown of municipal revenue in Canada and the United States. It is obvious from Table 4.2 that Canadian cities rely overwhelmingly on property taxes as their main source of revenue. In the United States, the main source of revenue are user fees. The role of user fees in urban infrastructure is multi-fold. User fees can be used to finance new infrastructure, such as power plants. User fees can also be used to regulate the use of existing infrastructure. Full-cost pricing in transportation can force the motorist to pay the full cost of operating their vehicles and hence can reduce automobile use.

It is interesting to note that the transfer of funds from the federal government to the city are lower for Canadian cities at 1.3% compared with 3.3% in the United States. What is more intriguing for large Canadian cities is the fact that the federal and provincial governments in Canada collect more money from these cities than they transfer back. Consider Toronto where the federal government in 2000 collected \$20 billion in taxes from Toronto and returned only \$12.6 billion. Similarly, the provincial government in 2000 collected \$15.1 dollars in taxes from Toronto and transferred back only \$13.7 billion (Rusk, 2002).

Table: 4.2: Breakdown of municipal revenue in Canada and the United States

Source	Canada (%)	United States (%)
Property taxes	49.5	21.0
User fees	20.2	32.6
Other municipal source	1.3	13.5
Transfer from Federal government	1.3	3.3
Transfer from State/Province	21.0	23.4
Other sources	6.6	6.0

Source: Federation of Canadian Municipalities (FCM), 2001.

In addition, the provincial governments have, in the recent past, downloaded numerous responsibilities to municipal and regional governments. Such funding restrictions are preventing the needed investment in the infrastructure of urban areas. Some revenue sharing between the municipal and provincial governments has been witnessed recently. For example, Alberta dedicates 5 cents per litre from the gasoline tax for investment in transportation infrastructure. Similarly, Montreal's transit agency Agence Metropolitaine de Transport receives 1.5 cents per litre from the gas tax as well as \$30 per car registration fee to offer transit services. In addition, the Greater Vancouver Transportation Authority receives 11 cents per litre from the gasoline tax. Such measures help prolong the life and improve the quality of necessary services offered by the local government.

Different planning time horizons complicate matters further in the inter-governmental transfer of payments, which are necessary for the rehabilitation of infrastructure in Canada. Municipal plans cover developments over 20 years, while the federal and provincial governments disburse funds to regional and local municipalities on a two-year schedule. Therefore, federal and provincial grants often finance short-term regional and municipal concerns and issues; higher levels of government do not address the long-term regional planning needs. Given that the agenda for rehabilitation of urban infrastructure in Canada is currently being drafted, one can argue that plans for the construction of new infrastructure should be laid out for public debate. In addition, given that fiscal austerity is the reality of our times. This calls for alternative infrastructure development strategies. Thus one needs to promote urban form, which requires minimum additional infrastructure.

Attempts by municipalities to levy new charges have been shot down by the courts as these measure did not stand the judicial review. Consider Toronto's example where in

August 2000, Toronto City Council endorsed a proposal by the staff that proposed a 30 percent levy on the “increased value of land of residential projects of more than 100 units.”<sup>2</sup> The levy was intended to generate funds to build affordable housing. The policy was not incorporated into a bylaw; instead the Council referred to the levy as “implementation framework.” The development industry protested strongly against the levy and indicated that the new tax might force them to locate developments outside the City boundary in the outer suburbs. The Ontario Municipal Board (OMB) received two complaints from large developers in Ontario who protested against the levy that cost them millions of dollars. In November 2001, the OMB sided with Minto Byg Inc., a Toronto-based developer, accepting the argument that the funds generated through the levy were not used for activities related to the projects.

Higher development charges in the suburbs encourage developers to build low-density developments in the suburbs, which in turn promote greater automobile use because of higher trip ends resulting from low population densities. However, as mentioned earlier, the low-density development in the suburbs is associated with a very high cost of infrastructure provision that often is not recovered completely by the development charges.

Some municipal taxes are regressive in nature and may not generate the intended results. Consider, for example, the case of spatial variation in development charges, which may promote urban sprawl and increase the cost of infrastructure provision. Municipal governments use zoning to control the spatial layout of urban areas and to determine the nature and type of residential and commercial developments. New urban development is also a source of revenue, as municipalities charge developers for building permits to provide infrastructure.

From the developer’s perspective, labour and material costs do not necessarily vary over space within an urban real estate market. However, development charges, as well as property and business taxes, could differ from place to place within a municipality. Developers, being utility maximizers, treat development charges as costs and try to locate new projects where development charges are minimal. Real estate builders have long argued that development charges have played a significant role in determining their spatial choices.<sup>3</sup> Developers in the GTA have demonstrated a distinct spatial choice structure. For high-rise projects, developers have preferred the City of Toronto, with existing population densities in excess of 10,000-individuals/square mile. For low-rise

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<sup>2</sup> Abbate, Gay. The Globe and Mail. *Deal brings peace with developers as 30-per-cent levy quashed*, Jan 22, 2001, A15.

<sup>3</sup> Personal interviews with the GTHBA representatives.

developments involving detached and semi-detached housing, developers have overwhelmingly opted for the outer suburbs in the GTA.

The spatial choice of a developer is influenced by the cost of land. Land rents are considerably higher in Metro Toronto when compared with rents in the outer suburbs. High-rise construction requires less land per unit developed. Again, developers are utility maximizers and will opt for the type of housing that maximises their profits. In other words, developers will opt for the type of development with a lower development cost per unit. This also explains their decision to build high-density condominiums in the City of Toronto.

The above rationale does not explain why developers have not built high-density housing in the suburbs. Land rents are relatively lower in the outer suburbs. In addition, outer suburbs have a ready supply of developed or developable land. The above two factors help explain influences on developers' location choices. The type of development, i.e., high-rise versus low-rise, in fact depends upon the development charges. In the outer suburbs, developers are charged significantly higher development charges for apartments when compared with the inner cities. Table 4.3 presents development charges for selected municipalities in the GTA in 1999. Developers have long argued that high development charges for apartment units, relative to other types, in the suburbs have prevented them from building high-density neighbourhoods.

Table 4.3: Development charges/unit in select municipalities in the GTA in 1999<sup>4</sup>

Municipality	Condominiums	Others	Singles/Semis
Aurora	10455	15623	18149
Brampton	8243	14923	14923
Burlington	6544	9076	12034
Caledon	9205	14274	16658
Clarington	9614	14413	16087
E Gwill	9196	13194	15441
Etobicoke	1900	2681	3160
Georgina	10624	14446	16883
Halton	7176	10478	13456
King	9105	12401	14909
Markham	14646	16045	18980
Milton	7522	11825	12974
Mississauga	9002	14773	14773
Newmarket	6614	11187	12620
Oakville	8227	11476	14768
Oshawa	9326	14231	16002
Richmond Hill	12016	15605	18320
Scugog	9093	13801	15663
Toronto (pre-amalgamation)	1131	1617	1304
Uxbridge	8580	12160	14707
Vaughan	12661	16927	19303
Whit/Stouf	10301	14586	17339

<sup>4</sup> Source: Eland Land Inventory database, PMA Brethour

Whitby	9039	14049	15917
York (pre-amalgamation)	723	1057	1304

#### 4.5 Emerging Trends in Infrastructure Finance

Funding large-scale infrastructure projects is one of the major challenges that Canada faces today. The spread between the demand for new infrastructure and its supply has been increasing at a fast rate in the past decades. The socio-political constraints, which prevent introduction of new taxes, and the roller-coaster ride of the financial markets, which makes debt instruments less attractive, are making investments in infrastructure a challenging proposition. The current times of fiscal austerity call for innovative approaches to infrastructure finance.

The use of project finance has become popular in light of the constraints listed above. The project financing structure often reduces the overall risk of the project by allocating acceptable risks to each of the involved parties. Risks are allocated by giving due consideration to risk bearing capacity and the strength of each party. There is a provision of Special Project Vehicle (SPV), which allows sponsors to reap tax benefits for new enterprise. Final plan is highly leveraged with 70-85% debt financing and 15 to 30% equity financing.

The primary reason behind the popularity of project finance for capital intensive projects is that the financing does not depend upon credit worthiness of the sponsor/s or value of project's physical assets. Instead, financing relies upon on the performance of the project.

There are four types of project financing structures:

- Production payment
- Forward payment
- Co-financing with multilateral organisations
- Build operate and transfer (BOT)

Build operate and transfer and its various variants, such as Build operate own and transfer, Built Operate Own Subsidise and Transfer, etc. are the most popular and effective mechanisms used by sponsors to fund projects. These are often referred to as Public-Private Partnerships or P3s. BOT structure involves formation of a Project Company (SPV). The government then assigns a concession to the Project Company, which assists in acquiring the land and defines the time period for construction and

operation of the project. SPV then builds and operates the project for the concession period, which generally ranges from 10 to 20 years. SPV then transfers project's assets less liabilities to the host government. Transfer of the project takes place with or without any compensation to the Project Company.

The above-mentioned process is strengthened by its various agreements and contracts between SPV, sponsor, supplier, operator and the host government. The essential purpose of all these agreements is to allocate risks among the stakeholders, and eventually reduce the overall risk of the project. An agreement ensures that the parties responsible for delay or default pay for their mistakes and at the same time bonus is awarded for early completion or successful operation of the project.

In the Canadian context, the financing of major infrastructure improvements can be made possible by using project finance. This requires co-operation between various the tiers of governments where local infrastructure needs are financed by project finance made possible by the backing/guarantees of the provincial/federal governments.

As mentioned earlier that the case for private financing of public infrastructure has been widely advocated for the reasons that such arrangements are more efficient, they allow for explicit recognition of risks, and expose new sources of low-cost funding. However, private finance is not free from problems. In the case of transportation infrastructure, the large high-risk investments, which are often indivisible into smaller units, make projects unattractive for private investors. In addition, financing charges for the private sector funded projects are often higher than private sector projects. There is often the risk of monopoly profits gained by the private sector proponent if alternatives to the new infrastructure are not available. Moreover, the state has to offer guarantees that can force the state in a bind. And last but not the least are the differences in the objectives between the private proprietors and the government, which may cause additional conflicts.

#### **4.5.1 Canadian Experience in P3s**

The Public Private Partnerships or P3s are slowly becoming popular in Canada. The government of Ontario initially financed the toll-road facility, Highway 407, running east-west to the north of Toronto. The private sector undertook the design and maintenance of the project. Later in 1999, the provincial government sold the asset to a private consortium for \$3.1 billion. Similarly, the Confederation Bridge, which links Prince Edward Island with New Brunswick, and the Colequid toll Highway in Nova Scotia are also examples of P3s.

## **4.5.2 American Experience in Funding Transportation Infrastructure**

The transit infrastructure investments in the US have produced certain very interesting possibilities in the field of infrastructure finance. The following paragraphs we will describe a sample of currently used strategies.

### **4.5.2.1 State Revolving Loan Fund**

Using the grants available from the Federal Transit Authority, States can establish and operate Revolving Loan Funds to support both public and private non-profit transit. Such an arrangement allows the states to fund transportation infrastructure improvements. Most recently, such funds have been used to allow vehicle purchases to cushion the large acquisition costs. Using the facility, funds are extended to transit operators who cannot acquire transit vehicles on their own. Loans could be extended on reduced interest rates (FTA, 2000).

### **4.5.2.2 Tax Exempt Bonds**

Tax Exempt Bonds (TEB) are often issued by a purpose-formed State entity using a particular revenue source or a physical asset to secure the debt instrument. TEB are used to lease assets, which are later distributed to transit operators. The resulting lease payments are forwarded to bond holders by the State entity. The maturity of the tax-exempt bonds matches the lease term of assets financed by such bonds (FTA, 2000). TEB are, however, not free of criticism. The city or the transit facility indeed benefits from the TEB, which in fact is equal to the foregone federal and provincial taxes, ending up being the transfer of payment from the federal or provincial governments to the municipality (TD Economics, 2002).

### **4.5.2.3 Super Turnkey**

Super Turnkey (ST) falls under the BOT arrangements. ST entails the building and operating of a new facility by a project management consortium. A Turnkey manager directs the purchasing, scheduling and other processes of the facility. This arrangement reduces delays in the project completion and hence reduces the overall project costs since a unified command and control system is overlooking the entire project. The same consortium may also arrange for the financing of the project (FTA, 2000).

## 5.0 Durability Issues

Major infrastructure projects require large up-front investments requiring significantly large capital outlays, and involving much higher risks than many other areas. Significant earlier examples include the construction of the coast-to-coast railway in the earlier years of the Confederation, and the construction of the Trans Canada Highway in stages over the second part of the 20<sup>th</sup> century. In each case and in many other similar situations, the large investments needed and their costs, along with the high levels of risk involved could only be catered by the public sector. In addition, these railways and highways and other infrastructure form a large network requiring considerable coordination of all of the detailed activities involved. Again, in the earlier years, this coordination was available only from the public sector.

In recent decades, significant projects have been planned and implemented with public-private sector partnerships (P3s), with the role of the public sector reduced significantly from that several decades ago. Recent examples include the Highway 407 in the Greater Toronto Area and the Confederation Bridge between New Brunswick and the Prince Edward Island. In each case, very large capital outlays were required, and it is contingent upon the parties involved in the projects that these investments were safeguarded and that there was an adequate return on these investments. This is possible only if these infrastructure facilities have a long technical service life to ensure a long economic service life over which the benefits can accrue to the owners and the public, along with adequate returns on the investment. Otherwise, the project would be doomed an economic failure.

As explained earlier, although each infrastructure facility is designed and constructed without any "clear agreement" on its desired service life, there is an un-communicated consensus among the owner, the engineer, the manager and the others involved that the system will have reasonably long technical, economic and functional service lives. This would enable the public to benefit from the infrastructure and for the owners to have an adequate return on their investment. Engineers are trying to come to grips with this serious issue and it is only recently that the new Canadian bridge design code requires explicitly that the new bridges should have a service life of 75 years. Initiating with an overt or covert consensus or a formal agreement between all parties on the service life of a facility, the next most important need after construction, involving careful quality control, is to ensure

adequate inspection and maintenance of the system to enable it to at least last over the required service life with minimum routine maintenance.

The accumulated infrastructure deficit in Canada (federal, provincial, territorial, regional municipal and others) was about \$ 100 billion in 1996. If the present infrastructure deterioration is not halted, or at least slowed down considerably, this deficit would continue to grow exponentially and the deterioration would finally reach a stage where some of the infrastructure would have to be replaced at significantly higher costs to the tax payer. A detailed inventory of all of the infrastructure in Canada and its current condition will enable a reasonably accurate assessment of the rehabilitation needs over the near future (5-10 years). This exercise would simply upgrade these facilities to an acceptable level and would require considerably more financial and other resources than those being presently spent on the maintenance and rehabilitation of infrastructure by all of the parties involved. Unfortunately, as mentioned earlier, many municipalities do not even have an accurate inventory of the entire infrastructure in their jurisdiction and therefore, they are unaware of its condition - deteriorated or otherwise. Consequently, these municipalities have to manage their facilities with incomplete information, which, in turn, does not permit scientific and rational assessment of the "real" needs. The need for a suitable inventory of all of the infrastructure facilities in all jurisdictions along with their state of "health" cannot be over-emphasised. It is an urgent need and appropriate action needs to be taken as soon as possible.

## 6.0 Vulnerability of Canada's Infrastructure

Most governments of developed countries recognise the need for comprehensive disaster management strategies to reduce their vulnerability to natural and man-made hazards and to mitigate the potential impacts of these hazards. The aftermath of the September 11<sup>th</sup>, 2001 terrorist attacks have forced the civil engineers and other professionals to address the broader issue of the vulnerability of the infrastructure to both natural and man-made hazards. These critical infrastructure systems comprise not only our physical facilities, such as buildings, bridges, water supply, sewage disposal, energy, transportation, and communication systems, but also, information, food, agriculture, critical chemical and defence industries, banking and finance, postal and shipping services and national monuments. There is an urgent need to develop risk and vulnerability assessment techniques and resources to protect lives, property, critical infrastructure, essential services and the environment, and preserve the economic stability. It is generally accepted that the responsibility for planning, mitigation, preparedness, response and recovery after the disaster lie with the federal, provincial, regional and municipal governments in Canada.

This analysis for the various hazards consists basically of :

- Identification of the hazards
- Vulnerability analysis
- Risk analysis, and
- Risk management.

The hazard identification is designed to provide specific information about any potential situation which can endanger life or cause damage to property and the environment. Here, natural hazards comprise earthquakes, hurricanes, tornadoes, floods, landslides, volcanic eruptions, wild fires and ice and snow storms. The man-made disasters include wars, terrorist attacks with explosives, fire, harmful chemical, biological and radiological releases, deliberate dangerous and damaging accidents seriously hampering infrastructure functioning including water supply, sewage disposal and mass transportation systems.

Vulnerability analysis is aimed at evaluating susceptibility to a potential hazard of life, property, effective functioning of the governments, essential services and the society at large. This analysis would delineate the areas and the associated infrastructure and other

support systems that may be affected. Risk analysis uses the judgement based on history of incidents, local experience and best available technological knowledge and is designed to determine the probability of loss of life and/ or injury, and damage to property and the environment.

Risk management involves effective utilisation of emergency response resources, detailed information concerning hazards, vulnerability and risks, provision of action outline and plan review criteria, and simulation capabilities for training, and identification of existing response equipment and personnel.

From the above, it follows that the need for a detailed inventory of all of the infrastructure in Canada and its state-of-health, followed by an acceptable upkeep of the infrastructure cannot be overemphasised to reduce the vulnerability of the critical infrastructure to natural and man-made disasters. This infrastructure can survive the extreme events only if they are in the best-maintained and safe condition.

## 7.0 Where do we go from here?

### 7.1 Lessons learnt

The response rate to the 1995 McGill-FCM Survey of Municipal Infrastructure in Canada was 28%, representing about 55% of Canada's population. The following lessons can be drawn from this survey:

1. Several municipalities in Canada do not have an inventory of the infrastructure in their jurisdiction. Moreover, many of the municipalities that do have a partial or a more complete inventory of their infrastructure, do not have a detailed description and history of the condition of the various infrastructure facilities. A complete inventory of all infrastructure facilities with a detailed condition assessment of each facility will enable development of optimal repair and rehabilitation strategies with the limited budgets currently available.
2. The 1995 survey was limited only to the municipal infrastructure, and there is an urgent need to develop an inventory of the infrastructure under the jurisdictions of the territorial, provincial and federal governments and the private sector, and the details of their existing condition. This would enable effective management of all infrastructure in Canada besides reducing the vulnerability of the infrastructure to natural and man-made hazards.
3. Because of the importance of the infrastructure to Canada's productivity, international competitiveness and the quality of life of all citizens, it is important that all levels of government develop a National Infrastructure Policy, giving infrastructure a higher priority among all national issues, and be placed just after health in terms of political priorities. This Infrastructure Policy can delineate the rights of Canadian citizens vis-à-vis infrastructure issues such as clean water, safe disposal of all waste, etc. The Infrastructure Policy must also provide guidelines about due consideration of life cycle performance and costing of all infrastructure projects, innovative sources of funding, emphasis on upkeep and upgrading of existing deteriorated infrastructure, and others.
4. Many of the infrastructure problems faced by the various organisations and levels of government emanate from the present trends of considering construction costs only with no serious consideration given to the system performance over its service life. For that matter, many infrastructure owners, managers and engineers have no

knowledge of the system service life and its performance over that period. This serious oversight along with the budgetary constraints of the various levels of government in the eighties has led to serious infrastructure problems, including severe deterioration of many facilities due to the deferred maintenance. It is high time to break this trend and to ensure that all projects for new infrastructure or rehabilitation of existing deteriorated infrastructure include a detailed evaluation of the system performance over its service life, and appropriate provisions for maintenance or any necessary rehabilitation (at late middle, or later stages of the service life) measures are considered at the design stage. Regular inspection and maintenance of the facility need to be undertaken diligently. The infrastructure engineers need to learn from the other branches of engineering, such as aviation, automobile, nuclear and other similar industries.

5. Traditionally, most of the major infrastructure systems, such as railways, highways, water supply and waste disposal systems have been constructed and maintained by the appropriate government agencies. Private sector has become involved only recently in public-private partnerships (PPP) in some important design-build and operate projects in Canada and elsewhere. Because of the current trends, the various levels of government will not be able to cope with the infrastructure management issues in the future. It is absolutely essential to determine and develop new funding sources, such as the PPP and others, including establishing a Canada Infrastructure Bank, proposed previously by the authors.
6. Although different levels of government spend about \$20 billion annually on construction and related areas, only about 20% of this amount is spent on upgrading the deteriorated infrastructure to an acceptable level. This has led to a serious national infrastructure deficit of about \$125 billion presently. If this deterioration is not halted immediately, these facilities will continue to deteriorate at an escalating rate and at some stage, they will have to be replaced at much higher costs. It would therefore be prudent for all levels of government and the private sector to assign a higher level of priority to the badly needed rehabilitation projects to ameliorate the on-going deterioration in these facilities.
7. Recent efforts of the Government of Canada to fund the development of a Guide to Sustainable Municipal Infrastructure, being developed as a joint project between the Federation of Canadian Municipalities and the National Research Council of Canada must indeed be lauded. The Guide will provide the Canadian infrastructure owners, managers and engineers with the best current practices to be utilised in designing, building, and managing Canada's infrastructure for both new and existing facilities.

requiring rehabilitation work Any new survey should direct the municipalities toward this significant document which will be available in 2006. The use of this Guide alone should offer benefits to infrastructure owners with savings of several billions of dollars over the next decade.

8. Although the available information and the related management systems are being continually improved, there is a strong need to incorporate tools such as the Geographical Information Systems (GIS) to enable continuing improvement in the management of infrastructure and for a more effective utilisation of the available funds.
9. The 1995 survey clearly showed the deteriorating trends in some of the infrastructure facilities. However, the information was merely qualitative. Detailed surveys of the infrastructure systems in Canada will enable development of quantitative information. The analysis of this data will help with the assignment of appropriate objective repair and rehabilitation strategies and programs with the limited available funds.
10. The 1995 survey found that wherever “user pay” funding was used to support infrastructure development and maintenance, these facilities appeared to be in a better condition than the infrastructure facilities supported through general revenue funds.
11. Each of the municipal, territorial, provincial and federal governments have a useful role to play in the future development and maintenance of infrastructure in Canada. The emphasis on the infrastructure issues will vary from region to region and from sparsely populated towns to large cities. It would therefore be useful if the representatives of these governments, the infrastructure agencies and others involved with the related areas, conferred together at a special workshop or conference, to define the varying needs in the different regions and localities and develop some recommendations to implement the needs derived by consensus and the previously mentioned National Infrastructure Policy.
12. The total worth of Canada’s infrastructure has been evaluated between \$3 and \$5 trillion. However, the amount spent on maintenance, repair and rehabilitation is significantly less than 1 percent. The extent of research on infrastructure issues is minuscule by comparison, with absolutely minimal level of support from the federal, provincial and other research agencies. Unfortunately, this urgently needed research is considered to be “low tech” in nature and the various agencies assign infrastructure research a relatively low priority at their competitions. There is an immediate need to promote and undertake significantly more research in the various areas of infrastructure in Canada. It would be useful to establish a network of

Centres of Excellence in the area of infrastructure preservation and protection to deal with the diverse infrastructure needs in different regions of Canada in terms of upgrading and protection, and also to reduce the vulnerability of Canada's infrastructure to any future natural and man-made hazards.

13. Canadian universities and colleges must be encouraged to initiate courses on infrastructure management, maintenance and rehabilitation, and reduction of vulnerability and mitigation of natural and man-made hazards. These courses should be organised at the technician, undergraduate and graduate levels. These institutions should also be encouraged to initiate research on the various issues related to Canada's infrastructure. The Federation of Canadian Municipalities, professional associations and learned engineering societies and organisations should be encouraged to develop continuing education courses, workshops and special programs aimed at upgrading the knowledge of the engineers and managers in this area. In addition, organisation of special half-day workshops related to infrastructure issues should be arranged for elected federal and provincial politicians to provide them with a critical view of the importance of infrastructure to Canada and all its regions. It is important to note that during the period between 1979 and 1999 the Canadian real government spending on public universities declined by 30% per student, while the US real spending increased by 20% per student for the same time period (Association of Universities and Colleges of Canada, 1999).

## **7.2 Suggestions for the Future Surveys**

Based on the lessons learnt from the previous survey exercise, we propose the following suggestions for the design and administration of an infrastructure survey to be conducted in future. The primary difference between the two surveys is the use of information and communication technologies, which fundamentally change the nature of the survey processes. We are suggesting here that the new survey should be internet-based where respondents can log-in to a secured server and complete the survey. The primary advantage of this approach is that the survey can remain on-line and be used later as an updating tool. This will allow respondents to offer regular updates on the state of infrastructure within their respective jurisdictions. The one-time costs of digital survey design can help reap multiple benefits by transforming the survey from a one-time only exercise into an on-going monitoring of the infrastructure throughout Canada.

A comprehensive Canada-wide survey has to be administered to produce a complete inventory of the entire infrastructure in Canada – federal, municipal, provincial and territorial. The first step in this process is the design of a “draft questionnaire”, which

should initially be reviewed by a technical committee comprising of representatives from Infrastructure Canada and other specialist groups. The consultation process will result in a revised and improved draft of the survey questionnaire. The next step in the survey administration process is pre-testing. The revised draft of survey questionnaire can then be used in pre-testing, where the survey is conducted over a smaller sample. Based on the experiences and findings from pre-testing, the survey questionnaire can be revised again, and the final draft of the questionnaire should be produced for the large survey. A nation-wide survey can then be administered. Responses from the survey must be assembled in a relational/GIS-based database (electronic inventory) to allow for both spatial and temporal analysis of data.

The design of the survey instrument is primarily based on the objectives of the survey, which are to collect information on the state of infrastructure throughout Canada. The survey should go beyond tallying the number of infrastructure assets. Instead it should also collect information on the physical state of infrastructure, concerns of infrastructure managers, methods and techniques adopted for infrastructure management and financing, etc. The survey should also inquire about the infrastructure deficiencies in the respective jurisdictions, and the manner in which these were diagnosed.

### **7.2.1 Database of Survey Respondents**

Unlike the 1995 survey, which was administered to municipal agencies only, the new survey should be sent to the infrastructure departments of all municipal, provincial, federal, and territorial governments to develop an inventory of their infrastructure assets and their existing condition, and their proposed infrastructure programs. The population for this survey will consist of the infrastructure departments in the municipal, provincial, and federal governments, and the three territories.

With the help of FCM and Infrastructure Canada, a database of postal and electronic addresses of all survey respondents must be developed.

### **7.2.2 Consultations on Questionnaire Design**

As for the questionnaire for the 1995 survey, the proposed survey questionnaire shall be designed in consultation with the technical committee, comprising representatives from academia, FCM, and Infrastructure Canada. The technical committee can help revise the survey questionnaire. The revised questionnaire will then be used in the pre-testing stage of the survey on a small sample.

### **7.2.3 Web-based Survey Design**

A mail-back survey instrument was employed in the 1995 survey. Though the survey resulted in a significant response rate, the mail-back survey process is time- and labour-intensive. The text in survey methodology also suggests that the response rates are low for mail-back surveys. In addition, the subsequent digitisation of the survey responses for data analysis purposes utilises more time and financial resources.

We recommend that the future surveys should adopt the state-of-the-art information technology. The new survey could be internet-based. Therefore, the survey form can be managed from a secured server on the Internet. Survey respondents will be able to log-in with their password and complete the survey on-line. Highest precautions must be taken to protect data against Internet theft and to ensure that the survey data remain well guarded during the data collection and subsequent stages. The respondents can complete the survey in multiple sessions, submitting the response only when the respondents are satisfied with the information accumulated. Since some municipalities may not wish to respond to an internet-based survey, the survey should be available to such entities on paper.

The first and foremost advantage of an internet-based survey is that the resulting database is populated automatically as the respondents complete surveys online. It eliminates the tedious, error-prone, and costly process of digitising survey responses. In addition, the entire process comprising of database design, data collection, database cleaning and error-checking is streamlined, resulting in synergies that are not possible if the process is completed in multiple and independent stages. Since the process will automatically generate interim progress reports, survey managers can monitor the survey in great detail, which in turn can highlight any deficiencies and hidden errors in the data collection process.

The new survey should also add a spatial dimension to the collected information. The survey respondents can be encouraged to identify the location of assets, which will be geocoded using Geographical Information Systems (GIS). Survey respondents should be offered multiple options to identify the location of infrastructure assets using the spatial identification hierarchies established by Statistics Canada. Based on the level of spatial disaggregation of collected information, data could be geocoded to the six-digit postal code, Forward Station Area, Census Tract, Census Sub-division, or Census Metropolitan Area level. The added spatial dimension enhances the ability to explore regional and sub-regional differences in the state of infrastructure in great detail. In addition, survey results can also be presented as choropleth maps, which can facilitate decision-making processes.

There is always a need to maintain a balance between the need for information and the length of the survey. Experts in survey design argue that the response rates decline with the length of the survey. Therefore, survey designers are always faced with the challenge to obtain the required information while keeping the length of the survey to a minimum. For this very reason Statistics Canada administers a long and short-version of census forms where the long-version is administered to a smaller percentage of respondents. For the reasons mentioned above, we suggest that the survey design should recognise the need for balance between information needs and the length of the survey.

Since the new survey will be internet-based, great care should be taken in the layout and survey design focusing on the ease of navigation on the internet-based survey form. In addition, inter-active help and instructions on the internet-based survey form should be available allowing the respondents to obtain help and instructions at any stage in completing the survey by selecting the *help* button. We also recommend that survey questions should be phrased to avoid confusion and to ensure that the nomenclature adopted in the survey is interpreted the same way throughout Canada

#### **7.2.4 Pre-testing of the Survey**

Both paper and internet-based survey should first be pre-tested on a small sample of municipal, regional and provincial governments across Canada to identify problems with the survey design. Based on the responses collected in the pre-testing stage, the survey will then be refined before being administered to the entire population.

#### **7.2.5 Survey Administration**

Individual local, regional, provincial, federal, and territorial agencies constitute the sampling unit for this survey. The survey, therefore, is administered to the entire population of the infrastructure agencies of the local, regional, provincial, and federal governments. Sampling should be done only if it can not be avoided. Certain fine-tuning and weighting of responses may be required to account for the regional differences in the survey response rates.

For large surveys, the survey management process is critical to the successful execution of the survey. The survey management effects quality control, response rate, and cost control. The following steps outline the survey process:

- A letter from the survey administrator is sent to the respondents in advance. The letter should contain information on the forthcoming survey and a request for co-operation. Respondents are also asked to identify their preference for paper or digital survey.

- The survey form is mailed to entities that prefer paper-based survey, while information on the digital survey is transmitted to the entities that prefer Internet survey.
- The response rate is monitored during the survey period.
- Two reminders are sent to those who did not respond or to those whose response is not complete.
- If and when necessary, respondents may be contacted again to help clarify their responses.
- On receiving a complete response to the survey, an acknowledgement letter is sent to the respondent.

The accuracy of the analysis relies upon the quality and precision of data collected during the survey. There exist numerous sources of error in data collection, preparation and subsequent analysis. It is important for the statistical integrity of the results that a certain minimum precision threshold is maintained at the data collection and subsequent processes. Error-detection regimes must therefore be instituted in advance to ensure quality control and precision. In addition, appropriate precautions must be taken during the questionnaire design, identification of the survey respondents, and interpretation of the survey responses to ensure precision.

### **7.2.6 Development/Cleaning/Geocoding of Database**

The digital database is automatically populated with electronic responses. However, responses received on paper will have to be entered in the database. Once all responses are entered in the database, the process of data cleaning, error checking and geo-coding is initiated. The cleaned up database can be used later for data analysis.

The relational database should be stored in a digital format that can be readily imported in statistical analysis and GIS software. The entire process of survey design, survey administration, database design and variable specification, and statistical procedures must be documented in detail to help subsequent users with data interpretation.

The database resulting from this survey will have the potential to be merged with other databases from Statistics Canada and commercially available spatial databases. The GIS-enabled infrastructure database can be merged with complementing data sets as and when such data become available from Statistics Canada and other sources. The infrastructure database can continue to generate insights into the state of the infrastructure in Canada as complementing data enhance and enrich the initial infrastructure database. This can continue until another nation-wide survey of infrastructure is conducted at a future date.

## 8.0 Summary and Conclusions

The results of this study can be summarised and conclusions drawn as follows:

1. A brief historical background of the current infrastructure crisis in Canada is presented along with the results of two principal infrastructure surveys in 1985 and 1995/96. The condition and need of Canada's infrastructure are briefly compared with those of the United States and some European countries.
2. The present trends in infrastructure construction, maintenance, and renewal are reviewed and lack of financial resources and deferred maintenance are noted as the principal sources of the present crisis involving significant deterioration of Canada's infrastructure, requiring an investment of \$125 billion to bring all of municipal, territorial, provincial, and federal infrastructure up to an acceptable level. The reasons for this crisis are reviewed.
3. The background, the objectives and modalities of the 1995 McGill-FCM survey are briefly presented along with a summary of the principal findings for Canadian municipalities divided into four population groups. The most significant impediment was noted to be financial shortage, followed not closely by lack of staff, political inaction, red tape, environmental assessment and prolonged public involvement. The conclusions of the 1995 survey are summarily presented.
4. The 1993 \$6 billion Federal Infrastructure Program was considered to be successful in partially improving its basic condition and it was noted to have funded the most important programs in the various communities. However, in view of the present infrastructure crisis and the infrastructure deficit of \$125 billion, the scope of this program is too limited and there is a strong need to find innovative financial resources through public-private partnerships and the formation of a Canada Infrastructure Bank.
5. Some of the challenges facing the infrastructure development and management in Canada are reviewed briefly in the context of Canada's peculiar economic and demographic attributes. These issues include the pressures from economic productivity, suburbanisation and the cost of infrastructure provision, and the challenges and trends of finding funding sources other than property taxes, user fees and the transfers from governments. The concepts of high density and low density housing in the large cities and the suburbs are discussed along with their impact on the infrastructure needs.

6. The report deals very briefly with the importance of technical, economic and functional service life, and how the large investments in Canada's infrastructure can be safeguarded by detailed consideration of life cycle performance of all facilities and the finances associated with them. This is presented as a way to alleviate future infrastructure crisis resulting from the current focus on designing and building without much detailed attention to the maintenance and any region and rehabilitation during the facility service life.
7. The vulnerability of Canada's infrastructure to natural and man-made hazards is reviewed briefly and it is suggested that the critical and vulnerable facilities should be maintained well. This would increase their level of safety against any natural and man-made hazards.
8. The lessons learnt from the 1995/96 survey are summarily presented, and the following salient features and recommendation are noted:
  - a. Need for a detailed inventory of infrastructure in each jurisdiction along with its state of health
  - b. Extend the infrastructure survey to all infrastructure under the jurisdiction of regional, provincial and federal governments and the private sector.
  - c. Need to develop a National Infrastructure Policy.
  - d. Need for consideration of life cycle performance and costs.
  - e. Need for innovative sources of funding such as public-private partnerships and formation of a Canada Infrastructure Bank.
  - f. Need for increased emphasis on rehabilitation of existing deteriorated infrastructure.
  - g. Develop a well-defined role for the National Guide to Sustainable Municipal Infrastructure.
  - h. Need to incorporate GIS in the management systems for infrastructure.
  - i. Develop the infrastructure needs of the various region and cities (through a well-organised workshop).
  - j. Establish of Centres of Excellence across Canada to deal with research and development need in the area of infrastructure.
  - k. Encourage organisation of regular and continuing education courses to update the infrastructure knowledge of engineers and managers.

9. The report presents definitive suggestions for any future surveys. It is recommended that these surveys examine the entire infrastructure in Canada. These surveys should be internet based and conducted to develop not only a data bank of all facilities but also a detailed inventory of their history, expenditures, current condition and future plans of the organisation. Some recommendations are made for creation of a database, which can be updated at regular intervals and for the design of the web-based survey. The question of pre-testing and survey administration also reviewed briefly.

Respectfully submitted.

M. Saeed Mirza, Ph. D., ing  
Professor

Murtaza Haider, Ph. D.  
Assistant Professor

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