

Chapter 3

Section 3.02

Ministry of Transportation

Bridge Inspection and Maintenance

Background

Ontario has about 14,800 bridges. Approximately 12,000 of these are located in municipalities and are their responsibility. The remaining approximately 2,800 bridges are located within the provincial highway system and are the responsibility of the province. More than 70% of provincial bridges were built between 1950 and 1980, which gives the province's bridge infrastructure an average age of about 40 years.

In the past, bridges were expected to last about 60 years; however, current technology and design allow the bridges that are built today to last longer. High traffic volume, heavy trucks, and freeze/thaw cycles along with exposure to salt used for winter maintenance all reduce a bridge's lifespan. Regular maintenance, repair, and rehabilitation can largely offset the impact of these factors on a bridge's lifespan.

Responsibility for the safety and maintenance of provincial bridges is set out in the *Public Transportation and Highway Improvement Act* (Act). The Act requires that all provincial and municipal bridges be inspected every two years under the direction of a professional engineer using the Ministry's Ontario Structure Inspection Manual (Inspection Manual). The Inspection Manual requires these biennial

inspections to be a "close-up" visual assessment of each element of a bridge as well as its material defects, performance deficiencies, and maintenance and rehabilitation needs.

The Ministry of Transportation (Ministry) is responsible for provincial bridges, and municipalities are responsible for the bridges in their jurisdictions.

Audit Objective and Scope

The objective of our audit was to assess whether the Ministry:

- has effective systems and procedures in place to ensure that the bridges within its highway system are safe and in good repair; and
- conducts bridge inspections and the required maintenance, repair, rehabilitation, and replacement work on a timely basis and with due regard for economy.

Our audit included visits to the Ministry's head office and three of its five regional offices. We interviewed staff, examined documentation, reviewed the results of bridge inspections, and researched bridge management practices followed in other jurisdictions. We also accompanied ministry staff on bridge inspections to gain an understanding

of the inspection process and the challenges that inspectors face.

In the course of our audit, we engaged a structural engineering expert from another province to review the Ministry's bridge inspection standards and practices and to help us interpret the results of the bridge inspections. To obtain an independent assessment of the condition of four provincial bridges, we hired an engineering firm to re-inspect them using the Ministry's Inspection Manual.

In 2004, we conducted an audit of the maintenance of the provincial highway system, and one of our recommendations specifically related to the Ministry's bridge inspection processes. Our current audit included a follow-up on the status of actions taken on this recommendation. The Ministry's Internal Audit Services had also issued a report in September 2005 on bridge inspection processes covering the period from January 1, 2001, to December 31, 2004. The report, as well as its follow-up in 2007, resulted in improvements to areas such as the timeliness and accountability of the inspection process. As well, they were useful in determining the scope and extent of our audit.

MUNICIPAL BRIDGES

Although municipalities must inspect their own bridges in accordance with the Inspection Manual, there is no legislation that provides any provincial ministry with the authority to oversee municipalities' compliance with this requirement. Given that the majority of the bridges are within municipal boundaries, and recognizing that the province still has an overall responsibility for the legislation governing bridge safety, we conducted a survey of about 130 Ontario municipalities, to which almost 60% responded. Our objective was to obtain information on how municipalities kept track of bridge inventories, what systems they used for complying with and reporting on required inspections, and what their perspectives were on the current operating and funding arrangements. We met with representatives from 10 large municipalities to

further discuss their survey responses, and also met with representatives from the Association of Municipalities of Ontario and the Ontario Good Roads Association. The results of our survey and discussions are included in this report in the Municipal Bridges section.

Summary

PROVINCIAL BRIDGES

The structural engineering expert we engaged advised us that the Ministry of Transportation (Ministry) had established comprehensive standards for bridge inspection in the Ontario Structural Inspection Manual (Inspection Manual), and if the standards are followed, the required inspection procedures effectively enable structural deficiencies to be identified. The Ministry's standards had been adopted for use by a number of other Canadian jurisdictions. The Ministry is also conducting bridge inspections on a biennial basis as required.

The main safety risks related to bridge infrastructure are accidents, such as those caused by concrete falling, or parts of a bridge structure failing to perform their intended function of providing adequate protection to the vehicles travelling on the structure. We noted a number of areas where improvements to the Ministry's inspection and maintenance processes would help minimize these safety risks and ensure that these bridges for which the province is responsible remain safe, especially given the aging infrastructure. Our specific observations are as follows:

- According to the Ministry's assessment, more than 180 or 7% of provincial bridges were in poor condition, defined as requiring repair or rehabilitation work within one year of the bridge inspection. We found that, despite their being in most need of repair or rehabilitation, over one-third of these bridges were not included in the Ministry's capital work

plan for the upcoming year. The Ministry indicated that it takes a corridor management approach to prioritizing such work that considers factors other than the rated condition of the bridge. As well, the Ministry stated that any critical safety issues would be flagged during inspections and remedial work carried out immediately. However, our engineering adviser indicated that, often, a distinction was not made in the inspection report between deficiencies that posed a safety risk and those that did not.

- The Ministry had not ensured that information on critical elements within each bridge was accurate and that all elements were accounted for. The state of these elements is the key to determining a bridge's overall condition and estimating its rehabilitation costs. In addition, the Ministry's database of bridge inventory—the Bridge Management System—did not have information on the rehabilitation history for almost one-third of the bridges that were 40 years or older. Although this information might be available in a region's paper files or local database, the Ministry's prioritization, cost estimates, and timelines for bridge rehabilitation work would be enhanced if this information was made readily available.
- The Inspection Manual requires a detailed visual “close-up” inspection of each bridge element. Normally, this requires the closure of lanes and road shoulders to traffic. For example, without closing a lane, close-up inspection of the critical elements of certain bridges on Highway 401 in the Greater Toronto Area would not be possible, yet there have been no such lane closures for the past three years.
- We found several weaknesses regarding the process for ongoing oversight of inspections. For example:
 - The Inspection Manual stipulates that an inspector needs to spend at least two to three hours at a typical bridge site. How-

ever, inspectors were often conducting five or more inspections a day. For example, in the rounds of inspections between 2006 and 2008, we noted that 10 or more bridges were inspected by a single inspector in one day on 36 separate occasions.

- A significant change in the rating of a bridge's condition between inspections requires explanation and, potentially, a re-inspection. We noted that the latest inspection results showed an improvement in the overall condition rating of over 300 bridges, even though little or no rehabilitation work had been done on these bridges since the last inspection. In other instances, the overall rating did not change at all between inspections and reports from the previous inspections were carried forward without any changes. Although in many cases there were photographs on file to indicate that an inspection had been done, when there are no changes whatsoever from the previous inspection, the adequacy of such inspections should be followed up on, especially on older bridges, because, typically, a bridge's elements deteriorate as the bridge ages.
- We noted that regions tended not to complete many of the maintenance recommendations resulting from biennial bridge inspections. In two of the three regions that we visited, only about one-third of the recommended maintenance work was actually completed, and the third region did not track this work at all.

With respect to the procurement of major projects for bridge design and construction, we noted that the Ministry generally followed a competitive selection process. However, in many of the contracts for design services and construction oversight consulting that we examined, there were changes to the scope of work that resulted in a final price of at least 50% more than the original contract price.

MUNICIPAL BRIDGES

To ensure the safety of municipal bridges, municipalities are also required to perform biennial inspections in accordance with the Inspection Manual. However, there is currently no legislation that requires or even enables the Ministry of Transportation or any other provincial ministry to oversee municipalities' compliance with this requirement. There is no central database on the number of municipal bridges and the overall condition of these bridges.

Our survey of municipalities indicated that the average age of municipal bridges was generally older than provincial bridges—about 43 years. However, it was not possible to get a precise picture on the overall condition of municipal bridges or to make accurate comparisons between municipal and provincial bridges because there were many different systems used by municipalities to classify and determine the condition of their bridges.

Nevertheless, the majority of municipalities (85%) that responded to our survey indicated that they had a backlog of rehabilitation work. Large and growing communities generally did not have significant backlogs because their infrastructure was newer, but municipalities with a large number of bridges relative to their population and revenue base had more difficulty funding the rehabilitation of bridge infrastructure and therefore had more significant backlogs.

In recent years, the province has provided municipalities with one-time funding for municipal capital projects. The decision to make these funds available was often made on the basis of demographic information rather than need, the funds were paid close to the end of the province's fiscal year, and many municipalities were not able to properly plan and spend the money. For instance, a significant portion of the funds provided in 2008 remained unspent one year later. Municipalities told us that requirements for better asset-management practices supported by more sustainable provincial funding are needed to ensure safety and maximize

the lifespan of municipal bridges. A provincial–municipal working group is currently examining these issues.

OVERALL RESPONSE

Ensuring that Ontario's bridges are safe facilitates the continuous movement of people and goods, supporting the provincial economy. The Ministry values the Auditor General's observations and recommendations and is committed to taking action.

Ontario is proud of its reputation as a North American leader in bridge safety. Overall, the Ministry's procedures to inspect and monitor bridge conditions are comprehensive and adequate to ensure that bridges in Ontario are safe. Every two years, Ontario inspects all 2,800 of our provincially owned bridges. Since 2005, the government has increased infrastructure spending to maintain, rehabilitate, and replace bridges. Commitments include an increase of 50% or \$450 million over a five-year period to rehabilitate approximately 150 bridges throughout the province by 2013. Since 2004/05, the Ministry has built 75 new bridges and rehabilitated 388 existing structures.

Detailed Observations

BRIDGE INSPECTION PROCESS

The main objectives of an inspection are to ensure that a bridge is in a safe condition; to identify any maintenance, repair, and rehabilitation that needs to be done; and to provide a basis for planning and funding any required maintenance and rehabilitation.

Two of the Ministry's five regional offices mainly use in-house engineers to conduct bridge inspections. The other three regional offices outsource bridge inspections to private engineering firms.

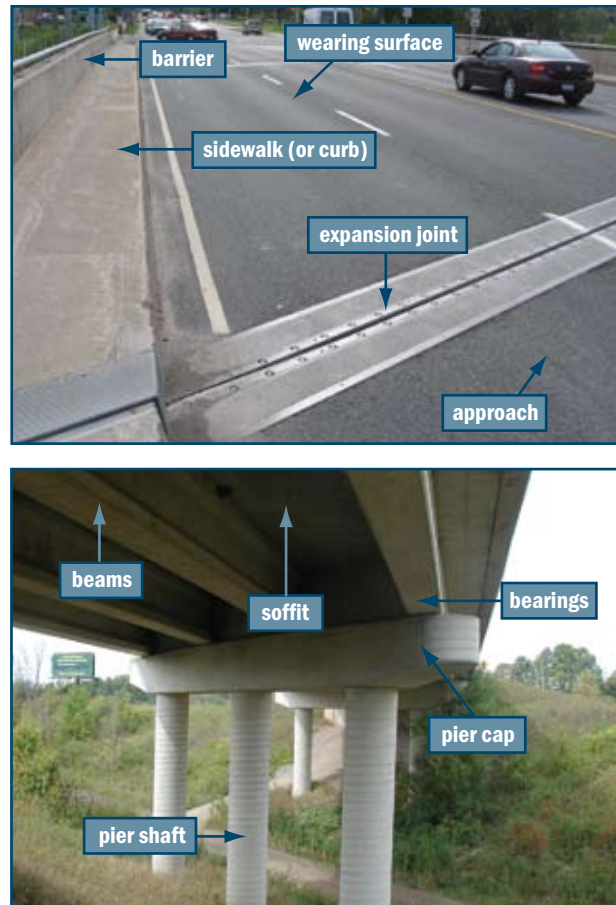
The time required to inspect a bridge varies with the bridge's size and design, but the average bridge typically takes about two to three hours. If during a visual inspection the inspector feels that more detailed information is needed, he or she can request specialized inspections, such as a deck condition survey or fatigue investigation. Also, the inspector is to notify the region immediately about any critical structural defects or deficiencies and any other unsafe condition discovered in the field, so that appropriate action can be taken.

To manage the inventory of provincial bridges, the Ministry uses a database called the Bridge Management System (System). It contains physical and historical information for each bridge, such as the length, number of spans, the area of each bridge element, the results from each inspection, and the condition each element is assessed to be in, from poor to excellent. Using this information, the System calculates a single value called the Bridge Condition Index, a measure of a bridge's overall structural condition and its remaining economic value expressed in a number between zero and 100. Bridges with a Bridge Condition Index of 70 or above are generally considered to be in good condition.

In 2006, the Ministry developed a Bridge Priority Tool to help prioritize major yearly bridge repairs and rehabilitation, and standardize the different priority-setting methodologies used by various regions. The development of the tool was part of a commitment that the Ministry had made in response to a recommendation in our *2004 Annual Report* to develop a framework to better manage its assets and to set priorities for sound investment decisions. The tool calculates a Priority Index for each bridge by modifying the Bridge Condition Index value after examining the condition of five critical bridge elements: the deck top, deck soffit, barrier wall, expansion joints, and concrete/steel beams. (Figure 1 is a photograph of two bridges with a number of these bridge elements labelled.) Each of these critical elements is assigned a "now need threshold" (the percentage of the element that

Figure 1: Elements of a Bridge

Source: Ministry of Transportation



is in poor condition and should be repaired within a year) and a weight (the importance of the element in relation to the entire structure). Bridges with a Priority Index of less than 70 are considered to be on the zero-to-five-year rehabilitation list; bridges with a Priority Index of less than 60 are considered to be a "now need," which means they should be rehabilitated during the next construction season.

The Bridge Priority Tool also estimates the cost of future bridge repair and rehabilitation needs. Each of the province's regions are supposed to use these rankings to develop a five-year capital work plan for repair and rehabilitation work. These regional plans become part of the larger provincial work plan.

We engaged a structural engineering expert to perform an independent assessment of the

Ministry's bridge inspection standards and practices. Our expert's opinion was that the Inspection Manual is comprehensive and, if its inspection procedures are followed, an effective means of identifying significant structural deficiencies in a bridge. Our expert also confirmed that the Ministry's methodology for prioritizing bridge repair and rehabilitation work is reasonable. We also noted that several other Canadian jurisdictions have adopted the Ministry's Inspection Manual.

CONDITION OF PROVINCIAL BRIDGES

According to the latest Priority Index that was available to us in June 2009, which included inspection results for up to the end of 2008, approximately 76% or 2,150 of the 2,800 provincial bridges were in good condition, 17% or 471 bridges were in fair condition but require work within five years, and 7% or 185 were in poor condition and need repair within one year.

Using its Bridge Priority Tool, the Ministry estimates that the cost of repairing and rehabilitating bridges in fair or poor condition over the next five years will be approximately \$2.2 billion. Yet the actual funds committed to the Ministry's budget for all bridge work over the next five years is \$1.4 billion, a shortfall of \$800 million. The Ministry has identified another spike in the need for major capital work over the next six to ten years as bridges continue to age: 70% of the provincial bridges were built between 1950 and 1980, and these older bridges have an average lifespan of 60 years. The Ministry has projected that an extra \$4.2 billion will be needed to repair these bridges.

In light of the expected shortfall, existing funds should be spent on bridges with the most urgent need for repairs. However, our review found that about 60% of bridges rated in poor or fair condition were not on the Ministry's five-year capital work plan. Specifically, of the approximately 185 bridges that were in the "now need" category in 2008/09, 71 bridges with repair and rehabilitation costs estimated to be \$190 million were not on the

Ministry's work plans for the following year. Ideally, bridges identified as "now need" would have been considered for repair and rehabilitation several years before they reach this condition, as sufficient lead-time is required to arrange for the necessary procurement work and ensure that safety concerns do not develop in bridges while they await scheduled repairs.

In response to our observation regarding the large population of bridges in fair and poor condition that was not on the work plans, the Ministry indicated that the Bridge Condition Index was a tool that measures the relative overall condition of a bridge and is not necessarily a measure of bridge safety. Any urgent safety issues would be flagged during inspections and remedial work would be carried out immediately.

Rather, the tool was being used primarily to assist with planning and prioritizing bridge rehabilitation work. In that regard, the Ministry indicated that, in response to recommendations from our 2004 audit, it has been taking more of a corridor management approach to its activities. Consequently, the condition rating of a bridge was not the only factor considered in prioritizing the timing of bridge rehabilitation work. In making the decisions, ministry staff applied their experience and judgment and took into account other safety and economic factors such as the role of a bridge, the kind of traffic it handles now and in the future and the cost savings expected through co-ordinating bridge work with other highway work.

The application of the sound asset-management principle is indeed key to setting priorities for bridge rehabilitation work and making sound capital investment decisions. However, we noted that the process was still in transition and the Ministry had not established formal guidelines for proper application of the principle. As such, the rationale and support for such decisions were often neither documented nor kept in the Bridge Management System. Better analysis and documentation of the safety and economic considerations are needed, particularly in

cases where the rehabilitation decisions were inconsistent with the condition rating of the bridge.

Furthermore, given the large proportion of “now need” projects that were not on the Ministry’s five-year work plan and the lack of documented rationale for their exclusion, we believe more attention needs to be paid to bridges identified as “now need” in the Ministry’s priority-setting process.

SAFETY OF PROVINCIAL BRIDGES

The primary objective of a bridge inspection is to provide assurance that the bridges inspected are in safe condition. In this regard, we engaged the service of an engineering firm (firm) to re-inspect four of the provincial bridges so that we could obtain an independent assessment of risks and the condition of those bridges.

According to the engineering firm, there are two main risks with respect to the poor condition of bridge infrastructure. One is the risk of accidents, which can be caused by objects falling and hitting traffic or leaving obstacles on the roadway below; or parts of the bridge structure failing to perform their intended function of providing adequate protection to the vehicles travelling on the structure. The other risk is related to the deterioration of property that could result in expensive repairs and rehabilitation over the long run.

The engineering firm concluded that, overall, the Ministry’s inspections were carried out in conformity with the intent of the Inspection Manual and that most critical features were recognized and pointed out. However, there were several notable exceptions where the risk of accidents could be serious:

- For all four of the bridges, the Ministry had not thoroughly inspected some significant bridge elements, including the underside, side faces, and piers because of traffic (see also the section Gaining Access to Bridges for Inspection). This could impede the effectiveness of the inspection and pose a serious risk (such as of concrete falling onto traffic).

- Our firm indicated that some of the features that can be seen or felt (for example, vibrations) can best be described in narrative form. Each critical bridge element on the Ministry’s inspection form is assigned a value from poor to excellent. Inspectors are expected to interpret what they see or hear and indicate on the inspection form the recommended timing of bridge maintenance work—from urgent to 10 years—where required. However, the inspectors’ assessment does not distinguish between deficiencies that posed a risk to safety versus deficiencies relating to loss of value as measured by the high cost of repairs, given the potential impact of the deficiencies identified. Our adviser was of the opinion that such information should be clearly communicated in the inspection report to provide assurance about a bridge’s safety and enable better planning of bridge work. For example, a ministry inspection report had called for repair of defects on some bridge surfaces within two years. However, there was no distinction made between surfaces and whether or not delaminated concrete could fall into Highway 401 traffic—an important piece of information for assessing the urgency of the repair work.
- Two of the four re-inspected bridges were rated in fair or poor condition and were therefore supposed to be rehabilitated within five years. The bridge that was in poor condition, in particular, was intended to be replaced completely in two or three years because of its deteriorated state. Neither of the two bridges, however, was on the Ministry’s five-year capital work plan.

RECOMMENDATION 1

To ensure that appropriate and timely action is taken on bridges requiring repair and rehabilitation work, the Ministry of Transportation should:

- strengthen its risk-assessment and priority-setting process, with particular consideration given to bridges identified as being in poor condition, so that any urgently required work is given first priority; and
- ensure that government decision-makers receive the information they require to adequately assess both safety and economic risks in order to prioritize the capital needs of Ontario's aging provincial bridges.

MINISTRY RESPONSE

Bridge repairs required to protect the safety of the travelling public are performed immediately. As shown by its long safety record, the Ministry has effective processes in place to address short-term urgent repair needs and long-term rehabilitation requirements. To build on the Auditor General's suggestion to further enhance and strengthen our risk-assessment process, we are implementing mandatory detailed documentation of bridge safety issues when identified by inspectors, clearer identification of potential safety risks, and recording of all bridge maintenance work that is completed. These enhancements will ensure that the Ministry further identifies bridges in need of additional repair and rehabilitation.

Backed by comprehensive inspection reports and engineering expertise, we have a multi-year work plan for bridge repair and rehabilitation. This plan carefully evaluates both bridge safety and economic risks to ensure the proper timing and location for capital improvements. New highway-infrastructure-management software will integrate a broader range of bridge condition and economic data to effectively prioritize bridge repair needs. The Ministry is also implementing even more rigorous criteria to enhance documentation of bridge repair work being undertaken or deferred.

BRIDGE INVENTORY

Effective bridge inspection requires complete and accurate information on the 2,800 provincial bridges and their individual elements. As indicated earlier, the information in the Ministry's bridge inventory is recorded on the Ontario Bridge Management System database, from which the Bridge Condition Index and the Priority Index are derived. These indices provide information about a bridge's overall structural condition and form the basis for prioritizing bridge repair and rehabilitation.

The Ministry's Inspection Manual lists over 50 elements that may be found in a bridge. Each bridge typically has at least 20 of these elements, and usually many more. Some examples of bridge elements are the deck-top, soffit (underbelly of the bridge), columns, and railing systems. During an inspection, the inspector is required to check if the bridge's structure and elements match its design drawings and the information in the database. If there have been any changes, the inspector must update the information in the database.

We found that the Ministry had adequate procedures in place for ensuring that it identifies all provincial bridges for which it has responsibility. However, the Ministry has not ensured the completeness and accuracy of its information on the individual elements that comprise each bridge. The Ministry cannot be precise in its rating of the overall condition of a bridge if the inspection does not assess the condition of each of the bridge's elements.

As part of its quality-assurance review in 2006 and 2007, the Ministry's head office re-inspected a sample of bridges that had been looked at by in-house inspectors or outside consultants in the various regions. For about 75% of the re-inspected bridges, at least one error was found in the way the information on bridge elements was recorded in the Bridge Management System. Examples of errors included missing elements and recording the wrong quantities or dimensions. About 40% of the errors found were considered to have had a significant impact on the condition in which the bridge was

rated and the resulting time frame for its repair or rehabilitation.

At the completion of our audit in spring 2009, the Ministry had not yet fully addressed the results of its quality-assurance review and some of the Bridge Management System information remained inaccurate. We also found significant differences between what was recorded in design drawings and in the Bridge Management System. For example, the dimensions of deck-tops in design drawings did not match what was recorded in the system for about 25% of the bridges in our sample. For more than 600 bridges, the dimensions recorded for deck-tops differed between different tables within the Bridge Management System. For approximately 200 of these bridges, the difference was greater than 20%, which would have a significant impact on the estimated cost of their repair and rehabilitation.

RECOMMENDATION 2

To better ensure that the results of bridge inspections are accurately recorded and to better prioritize and estimate the cost of bridge repair and rehabilitation, the Ministry of Transportation should:

- more closely monitor inspectors' compliance with the Bridge Inspection Manual so that critical bridge information is accurately updated; and
- act on findings from its quality-assurance review and ensure the completeness and accuracy of information kept in the Ontario Bridge Management System.

MINISTRY RESPONSE

The Ministry agrees with the Auditor General on the importance of inspector oversight. To ensure that this continues, a mandatory training program is provided to all bridge inspectors, clearly identifying specific roles, responsibilities, and requirements. Acting on the Auditor General's suggestion to further enhance bridge

inspections, a formal, rigorous oversight process has been implemented so that critical bridge information is kept current and recorded.

The large amount of data included in the Bridge Management System must be correct for it to be effectively used in decision-making. We are also acting on the Auditor General's suggestion to review our data for completeness, making additions and updates where necessary. We expect this review to be complete by late 2010.

GAINING ACCESS TO BRIDGES FOR INSPECTION

The Inspection Manual states that each element of a bridge is to be inspected in a systematic fashion. This means that an inspector is required to record observations, make sketches where appropriate, and take photographs that clearly show the structure and any defects found within it.

The Inspection Manual also calls for detailed visual inspections of bridges to be performed regularly. A detailed visual inspection is an element-by-element, "close-up" assessment of a structure's material defects, performance deficiencies, and maintenance needs. The Manual states that these inspections should be conducted within arm's length of the element, possibly involving tapping with a hammer or taking measurements by hand. In some cases (such as on structures that are generally in good condition) it may be possible to inspect a portion of a bridge up close and then estimate the condition of the remaining, inaccessible parts through extrapolation.

Thorough bridge inspections often require that lanes and road-shoulders be closed. Inspectors are responsible for obtaining the required approval for lane and shoulder closures through the Ministry's traffic department. However, we found that in the past three years there have been only a few shoulder closures and no requests for lane closures in the central region that encompasses the Greater

Toronto Area. When we questioned this, we were informed that it was virtually impossible to get approval for these closures in the Greater Toronto Area. In other parts of the province, closures are possible but were also not widely used as the disruption and expense is believed to be unwarranted.

In a 2006 training workshop, ministry inspectors and external consultants both commented that their work was challenged by not being able to gain adequate access to perform thorough, close-up inspections of large bridges. This issue is particularly serious in the Greater Toronto Area, where there are over 660 bridges on the 400 series of highways and some of them span up to 16 lanes of traffic. Half of these bridges are 40 years or older.

Having only limited access to bridges means inspectors may be forced to leave some elements uninspected, or to estimate the condition of some elements from afar, which increases the risk of inaccurately assessing their condition. Proper inspections of significant elements such as the soffit, beams/girders, or bearings may not even be possible.

The firm we engaged to re-inspect four of the provincial bridges confirmed that the lack of access represented a significant hindrance to the inspection because some surfaces could not be touched and some could only be photographed from afar or not at all. Some of these surfaces represent important sources of risk. For example, surfaces facing traffic on Highway 401 could not be probed for delamination, which on all concrete soffits will eventually lead to pieces spalling and falling off.

External consultants at the 2006 training workshop suggested that they work with ministry engineers to identify any required lane closures and that these closures be mandated in their agreements with the Ministry. The consultants added that the number of lanes to be closed should be specified when the work was tendered, to ensure that all consultants are bidding on the same scope of work. The reasoning behind this request is that if lane closures are optional, consultants bidding on the work might be tempted to omit the cost of

the closures from their tender. The Ministry has not acted on the consultants' request.

RECOMMENDATION 3

To ensure that inspections are carried out in accordance with legislation, the Ministry of Transportation should:

- arrange for the closure of lanes and shoulders whenever these are required to ensure that an adequate bridge inspection can be carried out;
- if closure of lanes and shoulders is not always possible for every bridge inspection, consider a risk-based approach that takes into consideration factors such as the age of the bridge and the feasibility of rotating inspections. Off-peak closures such as at night or on weekends also warrant more consideration to facilitate bridge inspection; and
- consider specifying lane and shoulder closures when tenders are issued for inspections to be done by external consultants.

MINISTRY RESPONSE

Ontario has some of the busiest highways in North America, making lane and shoulder closures very challenging. To build on the Auditor General's suggestions, we are acting on the suggestion to implement a risk-based approach to bridge inspection to ensure that lane closures occur on critical bridges; scheduling 75 traffic lane/shoulder closures this year in the Greater Toronto Area; and conducting a thorough review of all bridges across the province, starting with older bridges, where lane closures may be needed for effective bridge inspection. Lane closures will be mandatory for future inspections at these locations. In all cases where lane or shoulder closures are needed, we will work with our contractors to minimize impact to traffic without compromising the inspection process.

INSPECTION OVERSIGHT

Since its quality assurance review in 2006, the Ministry has carried out periodic re-inspections of bridges to check whether previous inspections were done in accordance with its Inspection Manual. The Ministry also conducts training workshops for ministry inspectors and external consultants that are aimed at improving the quality and consistency of bridge inspections.

These are good initiatives. Nevertheless, we identified a number of areas that we believe indicate a need for better oversight of bridge inspections.

Time Spent on Inspections

While the time required for a bridge inspection varies according to the type and design of the bridge, the Inspection Manual states that an inspector should plan to spend at least two to three hours at a typical bridge site to adequately assess the condition of all elements. Larger bridges take longer to inspect.

We noted that, on average, inspectors conducted three to five inspections in a single day. In the round of inspections done between 2006 and 2008, we noted that there were 36 instances where 10 or more bridges had been inspected by a single inspector in one day. Ten of these were inspections conducted by ministry inspectors and 26 were the work of external consultants.

Insufficient time spent on inspections increases the risk that serious deficiencies will be missed, especially in older structures and bridges that have a history of problems.

Changes in the Condition of Bridges between Inspections

In general, if a bridge does not undergo any rehabilitation between inspections, its value on the Bridge Condition Index would decrease as it continues to age and deteriorate. The rate of deteriora-

tion is slower at first but accelerates as the bridge ages. In trying to predict future bridge rehabilitation needs, the Bridge Priority Tool automatically reduces a bridge's Priority Index by 1.5% to 2% per year, depending on the age of the bridge.

A significant increase or decrease in a structure's Bridge Condition Index value between inspections raises questions: What are the possible reasons for the change, and what follow-up action should the Ministry take? When we compared the Bridge Condition Index numbers from current and previous inspection cycles, we noted that there was an increase or improvement of five or more points—not a decrease as would be expected—for over 300 structures. Recent rehabilitation work could only explain a few of these increases. Differences in the application of judgment on the part of the inspector was the reason most often cited for the increases that remained.

Conversely, we noted that for about 180 bridges, the Bridge Condition Index did not change at all between inspections. Our follow-up work indicated that the previous inspection reports had been carried forward for many of these bridges. Although in many of these cases there were photographs on file to indicate that an inspection had occurred, given that bridges do deteriorate over time, we believe that the absence of any explanation for why the bridge condition did not change warrants further follow-up.

In 2006, one region re-inspected 41 bridges that previously had been inspected by external consultants. It found that almost 20% of the bridges had Bridge Condition Index values that varied between 5 and 35 points from the initial inspection. Among other things, the review noted that inspectors were not consistently applying inspection guidelines or verifying bridge inventory data. The region concluded that better in-house expertise was needed to monitor the work of external consultants.

Bridge Condition Survey

If an inspector feels that more detailed information on a structure is required than can be learned in the course of a visual inspection, he or she may request further investigation. For example, the presence of severe material defects or performance deficiencies in the individual elements of a bridge may necessitate further investigation, which, for concrete bridge components, is usually in the form of a bridge condition survey. In a condition survey, procedures that are more precise than visual inspection techniques are used to assess the extent of the defects and deterioration in a structure. For instance, the Ministry has conducted condition surveys on only about 5% of the province's bridges in the last four years. Our expert indicated that, considering almost a quarter of the province's bridges are in fair or poor condition, one would have expected the Ministry to use the more comprehensive bridge condition survey more frequently.

Agreements with Engineering Firms

The regions that have outsourced the inspection of bridges have entered into individual agreements with the external firms they have engaged to do the work. We noted a number of substantial variations in the terms of these agreements. For example, one region had stricter requirements regarding experience (the inspector had to have at least five years of bridge-design experience in addition to being a professional engineer) and scheduling (there was a maximum number of hours that could be spent inspecting bridges in one day, inspections could only be carried out during daylight hours, etc.).

RECOMMENDATION 4

To ensure that inspections are conducted in accordance with legislation, the Ministry of Transportation should establish a risk-based approach for the ongoing monitoring of inspections. This approach should include:

- assessing the reasonableness of the number of bridges that external contractors and ministry staff report as having been inspected in any one day to ensure that thorough inspections are being done;
- following up on any unusual changes in a bridge's condition since the previous inspection; and
- identifying high-risk bridges that should be subject to more in-depth condition surveys.

The Ministry of Transportation should also consider standardizing its agreements with engineering firms. At a minimum, these agreements should contain provisions regarding the experience and qualifications of staff assigned by the firm to conduct the inspections.

MINISTRY RESPONSE

Thorough and accurate inspections are necessary to ensure bridge safety. To enhance the assessment of bridge conditions, we have implemented the Auditor General's suggestions to require ministry engineers to more clearly identify mandatory minimum timeframes for inspection and identify when unusual changes have occurred to the condition of a bridge. This will enhance the Ministry's ability to take the appropriate follow-up action.

Standardized inspection contracts have also been implemented that require specific experience and qualification requirements for all contractors performing inspections.

BRIDGE MAINTENANCE

During the course of a bridge inspection, the inspector is to identify the bridge's rehabilitation, repair, and maintenance needs. Future capital construction projects are to be included in the five-year capital work plan, whereas minor capital works in the \$100,000 to \$500,000 range are considered maintenance and are to be captured on a separate

list. Repairs to spalled concrete in columns or soffits and fatigue cracks in steel girders are considered maintenance work and would not appear on the Priority List and capital work plan.

There are two types of maintenance work. Structural maintenance is work that requires engineering drawings. It is generally done to improve the structural capacity of a specific bridge element or on bridges in need of emergency repairs. Routine maintenance is usually preventative maintenance and minor repair work carried out by bridge crews aimed at prolonging the life of the bridge structure. All maintenance needs are to be recorded on an inspection form and forwarded to the maintenance crews of the responsible region for action, with urgent items flagged for immediate attention. When maintenance work is completed, the region is to confirm that the required work, especially all safety-related maintenance, was performed satisfactorily.

We noted that regions did not always complete recommended maintenance work in a timely manner. In two of the three regions that we visited, only about one-third of the maintenance work recommended in biennial inspections was actually completed. The third region did not track the work being done, so we were not able to determine the number of maintenance recommendations that it had followed.

We noted that the procedures for acting on maintenance recommendations resulting from biennial inspections varied considerably between the three regions. For instance, only one region made any attempt to prioritize its maintenance recommendations into categories such as “low priority,” “high priority,” and “immediate attention.” This region was acting for the most part on recommendations that fell into the last category as well as a small percentage of its high-priority recommendations.

Finally, although the Ministry had started taking more of an asset-management approach to its maintenance activities, it had not yet developed a formal asset-management plan. Such a plan would

set out the optimal time frame in which to carry out preventative maintenance as well as the most cost-effective approach for managing bridge assets over their life cycles.

RECOMMENDATION 5

The Ministry of Transportation should:

- develop a formal asset-management plan as a basis on which to prioritize the preventative maintenance of bridges; and
- promptly carry out preventative maintenance, including the maintenance recommended in bridge inspections.

MINISTRY RESPONSE

All critical bridge safety needs are addressed immediately once identified by inspectors. In response to the Auditor General’s suggestion, we are currently creating a system to effectively prioritize maintenance work. This will be supported by consistent documentation of inspection results across the province.

The Ministry is implementing a program to more efficiently allocate capital resources for roads and bridges. Comprehensive multi-year regional work plans for all provincial roads and bridges will clearly identify necessary rehabilitation, replacement, and preventative maintenance. These work plans evaluate a broad range of criteria, including bridge condition, as well as effective value for money.

ONTARIO BRIDGE MANAGEMENT SYSTEM

As indicated earlier, the Ministry uses the Ontario Bridge Management System (System) to keep information on all provincial bridges. In addition to calculating a Bridge Condition Index value for each bridge, the System generates information on inspections, such as when they are due, the date of their completion, the name of the responsible

inspector, and the work that was recommended. This information is supported by photographs of defects observed during inspections.

The System was developed about 10 years ago to enable the Ministry and its regions to follow a more disciplined approach to managing the bridge inspection process. To ensure consistency and avoid duplication of effort, the Ministry's regions are supposed to use only the Ontario Bridge Management System. However, we found that each of the three regions we visited had been maintaining at least one additional local database. We noted the following issues:

- The Bridge Management System did not have information on the rehabilitation history for almost one-third of the bridges that were 40 years old or older. The Ministry confirmed that rehabilitation work had been done on some of these bridges in the last 12 years and detailed information was available in paper files or on the local database, yet none of this work had been entered into the System. Because the Bridge Priority Tool projects the next time rehabilitation work is due based on the information that has been entered into the System, the dates projected were inaccurate for work on some bridges.
- The System's design caused it to perform some operations slowly. In some cases, when a user logged on to launch a detailed view, the System had to retrieve data for all sites in the region or province, which meant it took longer to perform the operation. The System was also slow in generating detailed inspection reports because it involved assembling data from a number of different tables. Regional staff tended to use local databases because they contained data on fewer sites and were therefore much faster.
- The System has limited reporting capabilities. For example, there are a number of standard summary reports that generate information based on the latest data, but it was not possible

to generate these reports for a specific year—even though the required data was stored in the database. For instance, users could not query the system to flag large fluctuations in Bridge Condition Index values between inspections. The summary reports were also restricted in format. Users could not vary the layout of the reports to suit their needs.

The Ministry has made a number of upgrades to the System over the years. Despite these efforts, some of the above issues cannot be resolved because of the System's age and design limitations.

RECOMMENDATION 6

To make the Ontario Bridge Management System more useful, the Ministry of Transportation should:

- ensure that the information on bridge rehabilitation contained in the System is up to date; and
- assess whether the System meets users needs and whether there are cost-effective ways of improving its performance and capabilities, especially with respect to reporting information needed for rehabilitation and inspection purposes.

MINISTRY RESPONSE

The large amount of data included in the Bridge Management System must be comprehensive for it to be effectively used in decision-making. The Ministry is acting on the Auditor General's suggestion to develop a business case for making further significant bridge-management system enhancements, which would strengthen the Ministry's oversight of bridges in this province. We expect the business case to be completed in fall 2010. The new system, if implemented, would address all of the Auditor General's findings.

PROCUREMENT AND CONTRACT MANAGEMENT

Contract Selection Process

The Ministry outsources almost all the work for its major road and bridge capital projects. The services involved in this type of work fall into three categories: engineering design services, construction, and construction contract oversight. The Ministry generally followed a competitive selection process, but we noted some areas for improvement in its procurement of contracts for design services and construction contract oversight.

The Ministry has developed two separate sets of evaluation criteria to rank the proposals it receives for design services and construction contract oversight. In the first type of evaluation, 50% of the bidding consultant's score is to be based on its previous performance, and the remaining 50% is to be contingent on price. In the second type of evaluation, 50% of the score is to be based on the bidding consultant's previous performance, 40% is to be based on the technical merits of its proposal, and 10% is to be contingent on price. We were informed that for straightforward, clearly defined projects, the first set of evaluation criteria would be used. For more complicated projects, where the consultant's qualifications, approach, and ability to deliver are considered crucial elements, the second set of criteria would apply.

We agreed that, for certain projects, qualitative considerations are as, if not more, important as price. However, for the second set of criteria in particular, the Ministry could not adequately support the weighting it had chosen to use—price was virtually irrelevant given that it received only 10% of the weighting. In these types of projects, a contractor pre-qualification process would have allowed the Ministry to learn more about contractors in advance and put more weight on pricing in its formal requests for proposals.

The Ministry also was not clear about when and where each set of criteria would apply. The three

regions we visited varied significantly in their application of the two sets of evaluation criteria. One region had decided to use only the first set of criteria, while the other two regions were using both.

For nearly 60% of the contracts we reviewed, there were no more than two bidders. When there were no bidders, the Ministry ended up assigning the work to a consultant already engaged by it on another project. According to the Ministry, there has been a significant decline in the number of consultants bidding on design services and construction oversight contracts because of consolidation in the consulting industry. Recognizing this, the Ministry prepared a business case in September 2008 asking to increase its complement of staff so that it might reduce its dependence on external consultants. If approved, the Ministry would, although continuing to use consultants, gradually increase the number of projects done in-house over a five-year period.

Price Estimates and Change Orders

We noted that in over 60% of the contracts we reviewed for design services and construction contract oversight, the Ministry's cost estimate differed significantly from that of the selected bidder. In many cases, the winning bid was 50% higher than the Ministry's own initial estimate.

We also noted significant change orders after contracts had been awarded. Change orders occur when the consultant performs work that was not included in the original agreement. This could be due to an unforeseen requirement for extra work or additional materials, or a change to the scope of work because of new information uncovered during the project. We noted addenda in about 75% of the contracts that we reviewed. In half of these, the added costs amounted to more than 50% of the original contract price.

RECOMMENDATION 7

To ensure value for money on major capital projects and fairness in its procurement process, the Ministry of Transportation should:

- review the application of its two different sets of evaluation criteria for requests for proposals to ensure that they are consistently applied across the regions;
- reassess the evaluation criteria in which the bid price is a relatively minor factor in selecting the winning bidder; and
- given the frequent significant variances between the Ministry's estimated cost of a project and the bidder's cost, examine its internal estimation process as well as the possible impact of the increased trend of relatively few bidders.

MINISTRY RESPONSE

The Ministry uses a fair, open, transparent, and competitive process to hire contractors, one that ensures good value for money. Our criteria for bid selection were developed by the Ministry in consultation with both industry and the Ministry of Government Services. Price continues to be a determining factor in the selection of most successful bids. However, the Ministry's experience has been that for more complex projects, an emphasis on price during the design phase reduces the implementation of innovative and more efficient designs and drives construction costs higher.

To ensure greater consistency and transparency in how the Ministry selects contractors, detailed guidelines now clearly identify contractors' responsibilities and project requirements. A program is being implemented to closely monitor and evaluate the difference between estimated and actual design costs. Once it is complete, we will evaluate and make adjustments, where necessary, to our internal estimating process.

MUNICIPAL BRIDGES

Condition of Municipal Bridges

Each municipality is responsible for the bridges in its own jurisdiction. As well, there is no central database on the number of municipal bridges and their overall condition. There is also no legislation that provides any provincial ministry with the authority to oversee municipalities' compliance with the legislated requirement that they conduct biennial inspections that assess the condition and safety of municipal bridges.

One objective of our survey of municipalities was to gain an understanding of the municipal bridge inventory and how municipalities report on the required biennial inspections. The 73 municipalities that responded to our survey were responsible for approximately 7,300 bridges. These bridges were, on average, older than the provincial bridges. They were 12 to 100 years old, with an average age of about 43 years.

Almost all of the respondents said they engaged outside engineering firms to conduct bridge inspections and used a variety of systems to keep track of municipal bridge and inspection data. For example, some have adopted the Ontario Bridge Management System and others rely mainly on data maintained by external engineering firms, spreadsheets, and paper-based systems.

Sixty-five (90%) of respondents indicated that, overall, their bridges were in good to fair condition. However, the definitions and systems used by municipalities to classify bridges vary widely, so it was not possible to provide an accurate picture of the overall condition of municipal bridges in Ontario, nor was it possible to make comparisons between municipal and provincial bridges.

Nevertheless, our survey indicated that municipalities are finding themselves in a situation similar to that of the province as the need for significant rehabilitation becomes more pressing for many municipal bridges. The majority (85%) of respondents have a backlog of rehabilitation work. The urgency of the backlog varies, with 45%

of municipalities having a backlog of one to five years, 25% between six to ten years, and 10% over 10 years.

The primary sources of municipal revenue are residential and commercial property taxes, development charges, and user fees. Large and growing communities generally do not have such significant backlogs because their revenue bases are larger and their infrastructure newer. On the other hand, some municipalities have a large number of bridges but a relatively small population and revenue base to support the rehabilitation of bridge infrastructure. Figure 2 illustrates the extent of this disparity using a few examples from the results of our survey.

Funding to Municipalities

In recent years, the provincial and federal governments have provided municipalities with funds to help them maintain their roads and bridges. Municipalities can use the funds for infrastructure or spend them on other capital priorities. The decision is at the discretion of the municipality, depending on the terms of the grant program under which it received the funds.

In 2004, the federal and provincial governments pledged a combined \$596 million (\$298 million each) over five years to improve Ontario's municipal infrastructure, of which \$112 million was earmarked for bridges. In addition, in 2005/06 and 2007/08, the Ministry of Transportation provided one-time grants of \$400 million to municipalities for roads and bridges. Other one-time grants for improving municipal infrastructure were also made

available through various provincial ministries in 2007/08: \$450 million under the infrastructure program and \$1.1 billion under the *Investing in Ontario Act*. The decisions to make these grants available were often made close to the end of the fiscal year, with little advance warning.

Many of the municipalities noted that, although they welcomed such one-time grants, this type of funding makes long-term capital planning difficult. Because it takes time to properly plan capital projects, obtain council and environmental assessments, and follow the proper processes for approvals and procurement, many municipalities were not able spend the money until long after they had received the grant.

During our audit in spring 2009, we looked at a sample of municipalities that had received grants in June 2008. We found that half of them had yet to spend a large portion of the grant money they had received almost one year later. Some municipalities told us that the significant one-time grants they had received had actually increased project costs—the influx of requests for proposals from various local governments flooded the market with several projects at the same time, and with only a limited number of contractors available to do the work, bid prices tended to escalate.

In addition, the province had little knowledge about the condition of the bridges in each municipality and their maintenance and rehabilitation histories. The province allocated funds using demographic information, such as the size of the population and the network of roads. As such, the

Figure 2: Municipal Capacity to Maintain Bridge Infrastructure

Prepared by the Office of the Auditor General of Ontario

	Overall				
	Population*	# of Bridges	Condition of Bridges	Backlog (\$ million)	Backlog (years)
Municipality A	108,177	823	fair to poor	117.5	19.5
Municipality B	62,563	242	fair	9.5	9.5
Municipality C	668,549	108	good	nil	n/a
Municipality D	892,712	139	good	nil	n/a

* As of 2006, according to Statistics Canada

province may not be allocating funds to the areas of greatest need.

On the other hand, some municipalities expressed concern that providing funds for only the bridges in poor condition, although urgently needed, penalizes municipalities that have consistently followed good asset-management practices in maintaining their bridges. Municipalities told us that requirements for better asset-management practices supported by more sustainable provincial funding are needed to ensure safety and maximize the lifespan of municipal bridges.

Accountability

We surveyed the accountability relationship in the management of municipal bridges in other Canadian provinces as well as six states in the United States. We found that Ontario and four other provinces have delegated the responsibility for the inspection and rehabilitation of local bridges to municipalities without making any provision for provincial oversight. The other jurisdictions we looked at either share or delegate the maintenance responsibility but still maintain an oversight role. For example, each state in the U.S. is expected to maintain an oversight role over the safety of its bridges through the National Bridge Inspection Standard.

In 1993, the Government of Quebec transferred responsibility for the municipal road network to municipalities. The Commission of Inquiry that investigated the cause of the September 2006 collapse of the de la Concorde overpass in Quebec found that there was ambiguity between the province's Ministry of Transportation and its municipalities over who was responsible for the maintenance, repair, and replacement of bridges on the municipal road network. One of the Commission's recommendations was that Quebec's Ministry of Transportation regain ownership of all bridges from municipalities with a population of less than 100,000, or at least assume responsibility for their inspection, maintenance, and rehabilitation. In

January 2008, Quebec adopted the Commission's recommendation.

In Ontario, representatives from the province, the Association of Municipalities of Ontario, and the City of Toronto began working together in December 2006 to reach a consensus on a new fiscal and service-delivery partnership between the province and the municipalities. This initiative, called the Provincial–Municipal Fiscal and Service Delivery Review, covered fiscal relationships, infrastructure, and the delivery of human resources. With respect to infrastructure, the partners agreed to launch a joint provincial–municipal process in fall 2008 to develop options for identifying responsibilities and funding arrangements for roads and bridges using recognized asset-management principles. At the time of our audit, a working group with representatives from the province and the municipalities was being established to follow up on the Review's recommendations. Its objectives will include identifying municipalities with insufficient resources to maintain adequate levels of investment in roads and bridges, and developing a mechanism to provide them with extra assistance. Our survey results seem to indicate that this initiative is supported by many municipalities. Accordingly, we have made some specific recommendations for both the province and the working group to consider.

RECOMMENDATION 8

To help ensure the safety and proper upkeep of municipal bridges, and as part of its current provincial–municipal review, the Ministry of Transportation should work with municipalities and other stakeholders to:

- review practices in other large provinces and U.S. states with respect to oversight of municipal responsibilities for bridge maintenance, with the aim of determining whether changes to the current accountability relationship are required;
- ensure that the condition of municipal bridges is consistently assessed, updated

every two years as required, and publicly reported;

- review the Ministry's funding arrangement with municipalities to ensure that the funds provided are effective in sustaining the proper maintenance and rehabilitation of bridges; and
- promote good asset-management practices.

MINISTRY RESPONSE

The province and municipalities are jointly examining options around responsibilities and funding arrangements for roads and bridges.

Currently, municipalities are responsible for bridges under their jurisdiction and the associated inspections in accordance with the *Public Transportation and Highway Improvement Act*. Should further changes be warranted as a result of the review, we would certainly consider making some recommendations.

In the interim, we continue to work with our municipal partners to develop best practices for roads and bridges, focusing on development of an inventory of assets, classification of roads, and a review of how to manage these critical pieces of infrastructure.