ACCELERATING HIGHWAY BRIDGE DEMOLITION
AN INNOVATIVE APPROACH

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ACCELERATING HIGHWAY BRIDGE DEMOLITION - AN INNOVATIVE APPROACH

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ABSTRACT: The Regional Municipality of York used a unique approach to construction staging for a new interchange at Highway 404 and Elgin Mills Road, which included the demolition of the existing two-span post-tensioned concrete bridge structure over the expressway within a single 12-hour night-time highway closure. A highway closure was arranged to perform the bridge demolition from Saturday, December 13, 2003 at 10:00 p.m. to Sunday, December 14, 2003 at 10:00 a.m. so that the bridge could be demolished. As a result, traffic on Elgin Mills Road and on Highway 404 was impacted for only twelve hours of the entire two-year construction period.

1. INTRODUCTION

The Regional Municipality of York is located in the Greater Toronto Area, having a total area of approximately 1,800 square kilometres, bounded by the City of Toronto to the south, Lake Simcoe and the Holland Marsh to the north, Peel Region to the west and Durham Region to the east. Nine municipalities are located within York Region and consist of Richmond Hill, Markham, Aurora, East Gwillimbury, Georgina, King, Newmarket, Vaughan and Whitchurch-Stouffville.

York Region is experiencing one of the most rapid growth rates of any municipality in Canada due to extensive urban development. The Region's population in 2003 was 855,000 and is expected to reach 1.28 million in 2026.

Elgin Mills Road serves as a major east-west arterial roadway within of the Regional Municipality of York. The roadway is located in both the Town of Richmond Hill, west of Highway 404, and the Town of Markham, east of Highway 404. The limits of this particular project, as shown in Figure 1, are within a four-kilometre section between Bayview Avenue and Woodbine Avenue.

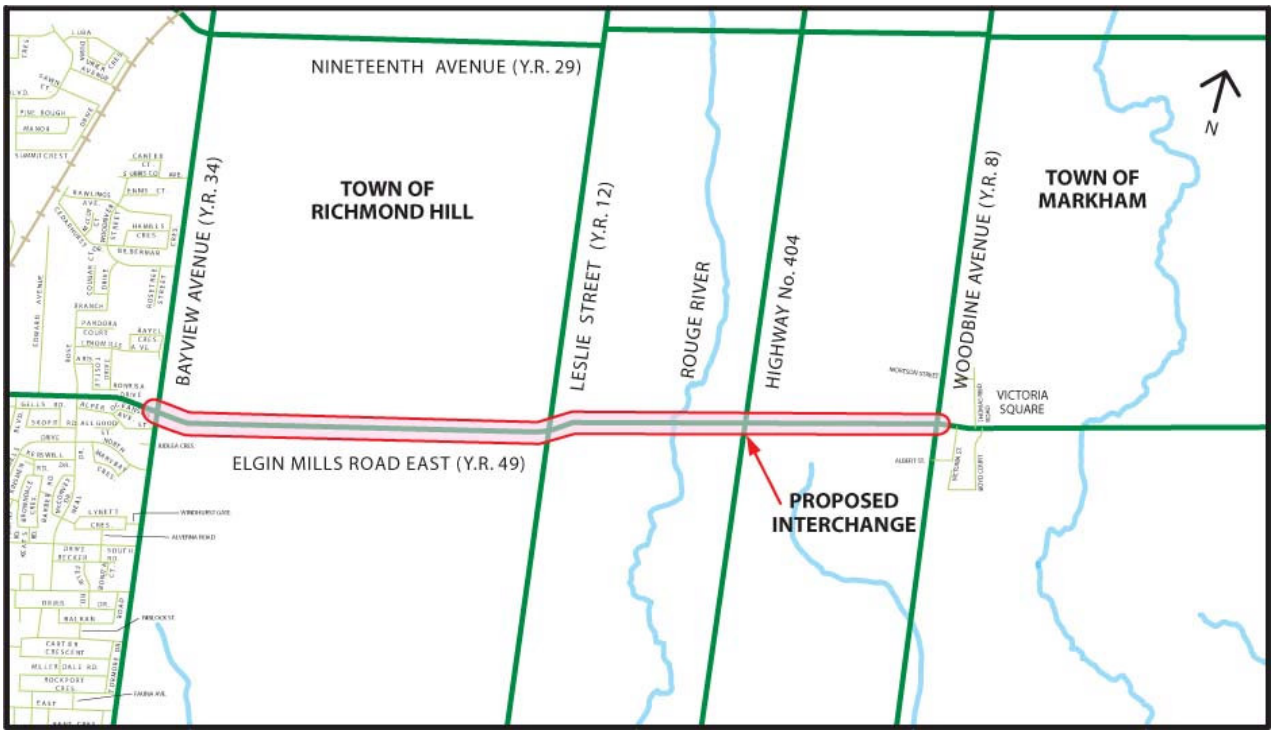

Figure 1. Key Plan

2. PROJECT BACKGROUND

The two-lane section of the existing road did not have sufficient capacity to accommodate the proposed new developments. To address this traffic capacity issue, the project followed the planning and design process of the Class Environmental Assessment for Municipal Road Projects, June 1993, prepared by the Municipal Engineers Association of Ontario. The proposed widening of Elgin Mills Road was classified under the category of a Schedule 'C' project.

The Elgin Mills Road Class Environmental Assessment study included an extensive public consultation program so that stakeholders had an opportunity to participate in the planning process, and to provide input as the study proceeded.

After evaluating the alternatives, the chosen solution was to reconstruct and widen Elgin Mills Road from Bayview Avenue to Woodbine Avenue and provide direct access to Highway 404 by constructing a new, full movement interchange, as shown in Figures 2 and 3. The existing two-span, post-tensioned concrete bridge structure over Highway 404 would be replaced with a new grade separation, wide enough to accommodate four lanes and ramp lanes on Elgin Mills Road, with clearance to span six lanes of Highway 404.

Figure 2. Proposed Interchange and Road Widening

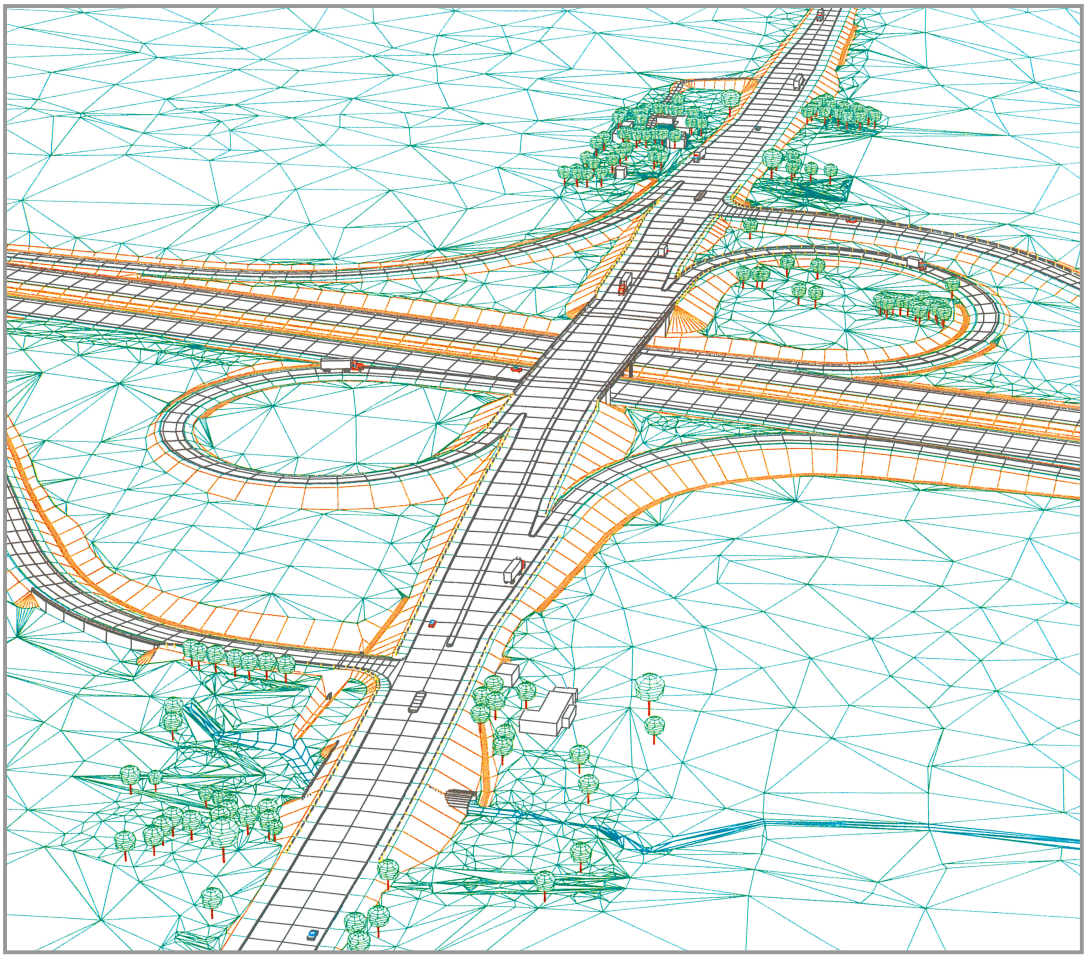

Figure 3. 3-D Rendering of the proposed Elgin Mills Road Bridge and Highway 404 Interchange

Although various road alignments were investigated to avoid the removal of the existing structure, the conclusion was that the structure would have to be replaced. The original Highway 404 underpass bridge was a two-lane, two-span post-tensioned concrete structure that could not be widened to accommodate the proposed ramp lanes of variable width, nor could the minimum vertical clearances over Highway 404 be provided during construction.

3. PROJECT OBJECTIVE AND SOLUTION

Traditionally, the construction of a new interchange involves the detour of highway lanes to a new temporary alignment in order to demolish the existing bridge structure and make way for the proposed structure. This temporary realignment of the six lanes of Highway 404 would be expensive and would add several months to the construction schedule, without adding value to the overall project. The challenge was to develop an innovative approach to construction staging that would least impact the public, and that would be an economical alternative to a full highway detour. The entire project had to be completed within a two-year construction schedule.

A different approach to construction staging was developed on the basis that the existing two-span post-tensioned concrete bridge could be removed within a twelve-hour period. During the Class EA in 1999, RVA proposed this concept to the MTO[1]. Although MTO had used this method for the removal of a small bridge in Northern Ontario, it had not been applied at that time in the Greater Toronto Area. It also had not been applied to the removal of a large structure over a major expressway with much higher traffic volumes such as experienced on Highway 404, which accommodates over 100,000 vehicles daily. After much consideration, MTO endorsed this approach for the Elgin Mills Road Bridge.

4. CONSTRUCTION STAGING DESIGN

It was important that both the MTO (the Owner) and the Region (the Client) were comfortable with this approach. During the Class EA, it was recognized that removing the structure within a single night would be challenging, but feasible. During detailed design, the single-night demolition concept became an integral component of the construction staging plan. The specifications outlined the performance requirements, and left it up to the contractor to develop the details for implementing the demolition.

Two-way traffic on Elgin Mills Road had to be maintained on the existing structure until the bridge was replaced. Therefore the proposed bridge structure would be constructed in two sections within three construction stages as follows.

[1] Although the concept was first presented to MTO in 1999, MTO subsequently applied this method for the removal of two other bridges in the Greater Toronto Area, during the period between 1999 and 2003.

Stage One - During the first stage, a portion of the new structure would be constructed on the north side of the existing expressway overpass, while traffic on Elgin Mills Road would be maintained on the original structure (Figure 4). The new interchange's on and off ramps would be constructed at the same time, to base asphalt for the detour of highway traffic around the site. A temporary connection would be needed for the detour of northbound expressway traffic to complete a connection between the off-ramp and the on-ramp.

Stage Two - Once the north portion of the new bridge was constructed, the existing post-tensioned deck and pier would be demolished in one night, as depicted in Figure 5. During this time, the six lanes of Highway 404 would be closed at 10:00 p.m. on a Saturday night. The expressway traffic would be temporarily reduced to one lane in each direction and detoured to the newly constructed interchange ramps. Elgin Mills Road would also be closed on either side of the interchange. The bridge would then be demolished. Following the demolition, all expressway lanes would be re-opened by 10:00 a.m. on Sunday morning. The temporary connection between the northbound off-ramp and on-ramp would be removed and the interchange ramps would then be closed until all other contract work was completed.

Stage Three - In the final stage traffic on Elgin Mills Road would occupy the new structure. The existing structure's abutments would be removed and the remaining portion of the proposed bridge structure would be constructed in the location originally occupied by the existing bridge, consisting of foundations, abutments and piers, retaining walls and deck (Figure 6).

Once all other contract requirements were completed, the interchange would then be opened to traffic.

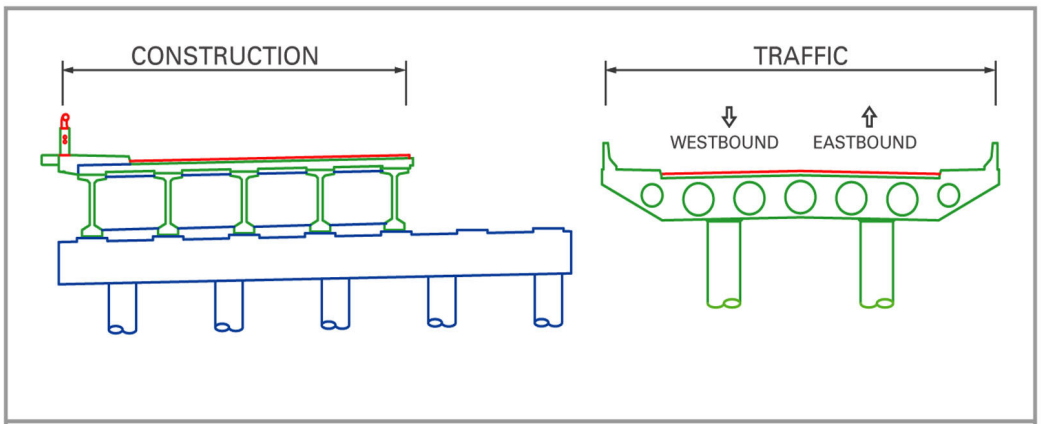

Figure 4 - Stage One - Construction of North Portion of Proposed Bridge

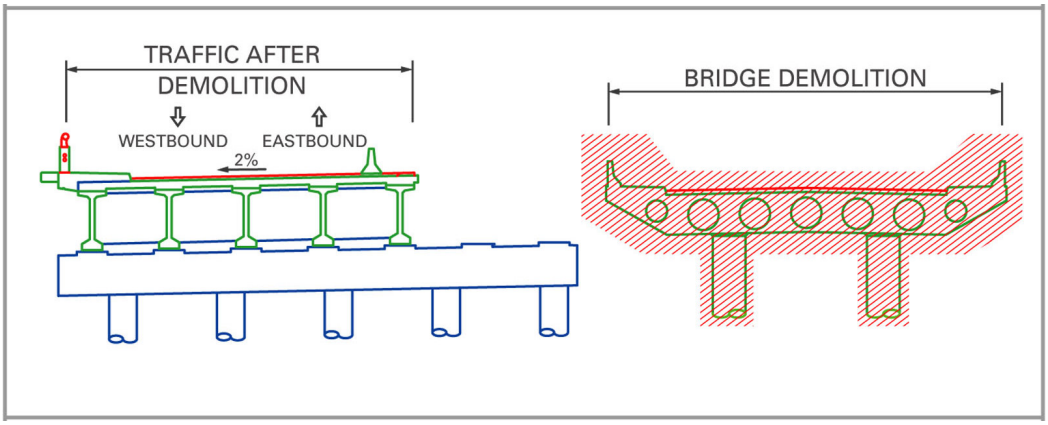

Figure 5 – Stage Two – Demolition of Existing Bridge

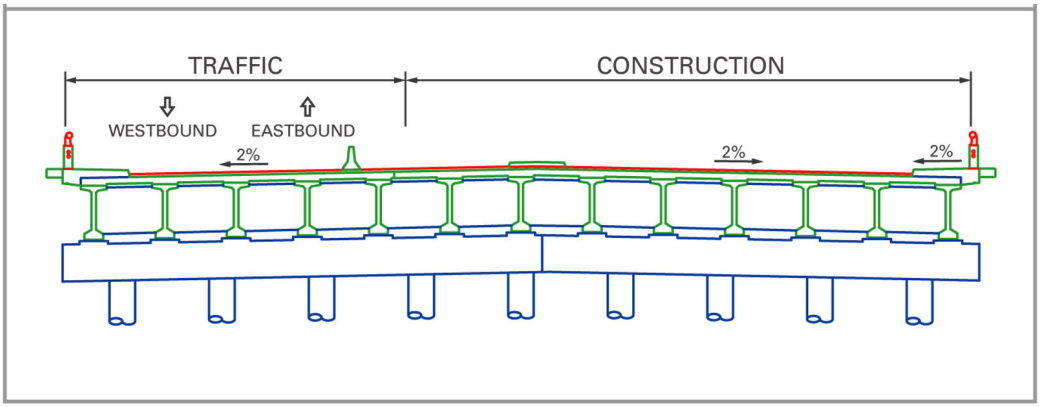

Figure 6 – Stage Three – Construction of Remaining Portion of Proposed Bridge

5. CONTRACT REQUIREMENTS FOR PLANNING THE DEMOLITION

The contract detailed explicit requirements for the timing of the 12-hour highway closure, to allow for the demolition of the existing bridge deck and piers in a single night. However, the existing abutments and pier footings could be removed afterwards, since they could be demolished without affecting expressway traffic operations.

The contractor was responsible for preparing a Demolition Plan for approval by the Ministry of Transportation of Ontario. The plan had to present a step-by-step procedure, addressing all aspects of the structure demolition, in one-hour schedule increments. The procedure had to include measures for protection of the existing expressway surfaces from falling debris, as well as the removal and cleaning of the expressway surfaces prior to opening all six lanes to traffic. The contractor was required to have one standby piece of equipment on site for each piece of equipment being used for the demolition, in the event of equipment breakdown.

The contractor's traffic control design had to include effective means to manage the safe diversion of traffic using crash truck protection, variable message signage, advance warning signage for the highway closure, paid duty police and flagging to keep the traffic detour moving without interruption. The contractor was also required to prepare a Communications Plan to provide advance notification to the public. The Communications Plan was to include newspaper and radio advertisements, notification to all emergency services, advance signage and COMPASS notification.

The contract stipulated stiff penalties to the contractor if the bridge demolition delayed the opening of the expressway past 10:00 a.m. the following morning. If all lanes were not opened by the specified time, the contractor would be assessed an initial $50,000 penalty, and a further penalty of $50,000 would apply for every part of a 30-minute period that the expressway remained closed.

6. CONSTRUCTION IMPLEMENTATION

The construction of a temporary detour for the demolition of the existing bridge can be a lengthy process. On the other hand, a bridge demolition during a single twelve-hour period can be risky, as a delay could seriously disrupt highway commuter traffic on the following Monday morning. The benefits of a fast-tracked schedule and cost savings were considered to outweigh those risks.

Demolishing a large concrete bridge in twelve hours is a complex procedure. The contractor presented a carefully thought-out plan, in order to provide York Region, the MTO, and RVA with the assurance that the work would be completed safely within the twelve-hour highway closing. The risk of any delay had to be assessed, since the consequences of impacting commuter traffic during the following Monday morning rush hour would be serious. As such, the financial penalties that would have been imposed for delays in reopening the highway reflected the social costs that the public would have to bear.

It was important that weather did not postpone the proposed work, as the demolition had to be performed prior to the winter construction shutdown. Moreover, weather conditions could not delay the bridge demolition since the designated weekend had been announced weeks earlier, through advanced signage, radio advisories and police coordination. Coincidentally, the first snowstorm of the season occurred on the very same weekend the bridge was scheduled for demolition. However, the work did proceed as planned. As a result of the snowstorm, additional activities such as snow removal and de-icing of the pavement had to be completed before the highway could be re-opened to traffic.

In addition, an unusually wet autumn delayed the interchange ramp construction. The ramps were originally to be used for detouring highway traffic around the demolition site. To avoid a potential five-month delay due to the winter shutdown, a contingency plan was put in place so that the demolition could proceed without completion of the

ramps. This plan allowed the contractor to detour the highway traffic to Woodbine Avenue, a nearby regional road, during the twelve-hour demolition period.
One week prior to the date of the demolition, a coordination meeting was held to review the contractor's demolition procedure, the traffic detour plan and the schedule.

Figure 7 - First Stage of Bridge Construction

Traffic Detour Plan - The expressway traffic in each direction used adjacent interchanges to detour traffic off the expressway onto Woodbine Avenue, an adjacent arterial road. The detour was approximately four kilometres long, and was monitored by police to ensure a continuous flow of traffic movement with minimal delays. During this time, Elgin Mills Road was closed to traffic. The public were informed several days in advance of the upcoming highway and road closures.

Schedule - Table 1 provides a summary of the demolition schedule.

Table 1 – Summary of Demolition Schedule

Time	Description
8:00 p.m. to 9:00 p.m.	Close Elgin Mills Road
9:00 p.m. to 10:00 p.m.	Set-up detour signage along adjacent Woodbine Avenue. Close the third lane of Highway 404 in each direction.
10:00 p.m. to 11:00 p.m.	Close last two lanes of Highway 404 and detour traffic. Set up temporary lighting of work area.
11:00 p.m. to 12:00 a.m.	Place granular pad protection and blasting mats on the expressway and mobilize equipment.
12:00 a.m. to 4:00 a.m.	Demolish existing structure and centre pier.
4:00 a.m. to 8:00 a.m.	Remove debris to outside the clear zone for future disposal. Install temporary concrete barriers to protect median.
8:00 a.m. to 9:00 a.m.	Final clean up of expressway surfaces with a sweeper and flusher.
9:00 a.m. to 10:00 a.m.	Re-open all lanes of Highway 404 and Elgin Mills Road.

Demolition Procedure - Protection of the existing expressway pavement consisted of a combination of 100 to 150 mm thick sand bedding and blasting mats to protect the surface from the impact of falling debris. A total of eight excavators equipped with hydraulic hammers and shears were on-site, three of which occupied each of the northbound and southbound lanes. The remaining two excavators remained on standby in the event of equipment breakdown. The hammers were used to break the concrete while the shears were used to cut the reinforcement and post-tensioning cables. The demolition commenced at the middle of each span from the south side, and preceded back and forth until all that remained was a narrow spine of concrete. This spine was then removed from the centre section, proceeding outwards to the abutments. The centre pier was the last section to be demolished. Once the bridge was demolished, the concrete was removed to the side of the highway to be broken down into smaller pieces for shipping to a recycling plant. Figures 8 to 12 depicts the demolition progress.

Figure 8 - Demolition commences with removal of parapet walls

Figure 9. Bridge demolition proceeds quickly.

Figure 10 – Centre piers remain following deck removal on either side

Figure 11 – Centre piers and deck on ground

Figure 12 - Bridge Demolition is Completed

7. SUMMARY

From the perspective of the public and the municipality, the success of any project is dependent on the ability to minimize impacts and inconvenience to traffic operations during construction, in terms of both delays and safety. Successful implementation of the work with minimal disruption to the public is a critical factor in establishing the success of the project.

The project objectives that were developed during the Class EA and detailed design were achieved with great success, thanks to a contractor that prepared and executed an effective work plan to meet the objective of completing the bridge demolition within the 12-hour timeframe.

The most significant achievement arising out of this innovative approach was that it avoided a long-term highway detour, maintained traffic on Elgin Mills Road, and was executed with minimum disruption to the public. The Region benefited through lower construction costs and a reduced construction schedule, since the construction of a highway detour was expected to cost over $2 Million and take over three months to complete.

ACKNOWLEDGEMENTS

Client *- Regional Municipality of York*
Consultant *- R.V. Anderson Associates Limited*
General Contractor *- Dufferin Construction Company*
Demolition Sub-contractor *- Priestly Demolition Inc.*

BIOGRAPHY

Cynthia Martin, P.Eng. - Ms. Martin is a Project Manager with the Regional Municipality of York. She possesses vast experience in the design and construction of transportation infrastructure, accumulated from her work in both the public and private sectors of transportation engineering and planning.

John P. Does, P.Eng. – Mr. Does is a Senior Associate of R.V. Anderson Associates Limited. He possesses over 18 years experience as a professional civil engineer, focusing on transportation engineering. He specializes in managing the design and construction of transportation infrastructure, including roads and highways, transit facilities, and new and rehabilitated structures. He has been involved in a large number of projects involving transportation structures, and acted as Project Manager on the Elgin Mills Road / Highway 404 Interchange project.