Executive Summary

The Avenue Road Watermain replacement was one of the City of Toronto's largest and most complex projects. Replacing the 100 year old watermain involved constructing in an established commercial district, crossing an affluent residential neighbourhood with heritage structures and tree lined streets, and traversing a busy traffic corridor that connects the northern part of the City with the downtown core. The challenging construction environment included a maze of underground utilities that had to be avoided or relocated to install 5.6 kilometres of 900 millimetre and 750 millimetre pipeline.

Associated Engineering's design incorporated both traditional open cut and trenchless construction techniques for pipe installation. This approach balanced the cost of more expensive trenchless techniques versus disruption caused by traditional open cut construction.

Through careful planning with City staff, the team identified locations in this crowded urban area for deep shafts to launch large tunnelling equipment and prevented disruption to water and utility services.

Employing trenchless techniques in critical areas mitigated significant risks of digging trenches through utilities constructed over the last 100 years, and minimized impact on businesses and commuters.

The team established and implemented a proactive communication program, including extensive public and stakeholder consultation as well as day-to-day communication with businesses and residents during construction to resolve any concerns. Through this process, the project team avoided negative media on this project which received intense media attention.

Strong design and construction management, positive communication, traffic management planning, and partnering between Associated Engineering, City of Toronto staff, and the contractor resulted in construction of the watermain while minimizing impact on residents, heritage structures, tree-lined streets, businesses, and commuters. Maintaining traffic flow along this congested commuter corridor, as well as water and utility services were key successes on this project, demonstrating that infrastructure can be replaced in busy urban areas while minimizing public impact. The new Avenue Road Watermain increases security of water supply to the City of Toronto and Region of York and supports future population and economic growth.

The team's attention to technical details, logistics, planning, and communications helped ensure project success while minimizing public impact.

Introduction

Background

Managing and replacing aging infrastructure and keeping up with growth and demand on infrastructure are issues faced by many urban municipalities all across Canada, and none more than the City of Toronto. The City's history dates back more than 200 years. Today, with almost 3 million people in the City and 5.5 million people in the Greater Toronto Area, the City's water infrastructure serves as a critical lifeline for the community. The City of Toronto has undertaken extensive planning to ensure the sustainability of its water supply.

Originally built in 1915, the Avenue Road watermain located in Central Toronto is one of the main water supply hubs serving the City of Toronto and Regional Municipality of York north of Toronto. The pipeline carries up to 50 million litres of water per day, which is enough to fill 20 Olympic-sized swimming pools.

Project Objectives

Through their planning, the City of Toronto determined that the existing cast iron watermain along Avenue Road needed to be replaced to increase the long-term security of the water supply and improve the water system's overall hydraulic performance.

The City of Toronto retained Associated Engineering to provide design and construction services for the Avenue Road Watermain Replacement Project. The project included installation of 750 millimetre and 900 millimetre diameter watermain along Avenue Road, a busy traffic corridor, north of downtown Toronto.

The project extended from the City's High Level Pumping Station on Cottingham Street, to the connection point at Avenue Road and Caribou Road. This watermain project also included the decommissioning of the existing watermain located along Duplex Avenue.

As well, a new 400 millimetre diameter watermain was required on Avenue Road, from MacPherson Avenue to Poplar Plains Crescent, to increase water pressure and supply to the distribution system situated further south of the project limits. In total, three trunk watermain connections and fifteen branch connections were made to the City's massive water system.

Solution

The main challenge for the project team was to mitigate the risks and impacts of installing the watermain in a congested urban area, with as much infrastructure and utility congestion below grade, as traffic and pedestrians above grade.

The design team specified constructing the watermain by employing trenchless construction techniques, which would help minimize construction impact on traffic, businesses, and the public.

To balance costs of more expensive trenchless construction as well as deal with location restrictions, some sections of the watermain were constructed using traditional, open-cut trench installation.

The construction techniques were selected considering the possible impact on heritage

sites, tree-lined streets, businesses, residents, schools, and their students. The final design included 2.8 kilometres of open cut and 2.8 kilometres of tunnelled watermain.

Complexity

Location constraints

Avenue Road is a major thoroughfare in central Toronto which connects the north end of the City to the downtown core.

Construction of the new watermain required lane closures and reductions, construction in a local park, sidewalk detours, temporary transit relocations, restricted access to driveways, and temporary disruption to water service, all of which had to be conducted with minimal impact on local residents, businesses, and schools.

Managing and maintaining smooth traffic flow through the area was critical. The team developed a strict traffic management plan, which mandated maintaining one lane of traffic in each direction at all times.

The team developed a construction staging plan that considered the technical, community, and contractor's requirements. Allowances were made for the contractor to use the road to carry out work, thus helping to control and reduce overall construction costs.

The project site consisted of a relatively small footprint and was surrounded by congested roads. This made for a challenging setup and for the operation of the heavy tunnel boring equipment.

Further adding to the complexity, some of the micro-tunneling launch shafts were as small as 8 metres by 4 metres in size. This required the team to conduct very careful planning and develop construction staging plans that positioned the working space and the equipment alongside the tunneling route.

The two-year project was one of the largest and most complex undertaken by the City of Toronto.

Geological conditions

Excavating deep shafts, some within two lanes of traffic, was a notable challenge. Complicating matters was the previously disturbed nature of much of the tunneled silts and sands from previous construction, both below and above the tunneling alignment.

While the selected tunnel-boring machine was capable of handling a wide range of ground types, including soft clay and rock, the design team had to address a long section in the ground that produced high jacking forces, due to the natural properties of the soil.

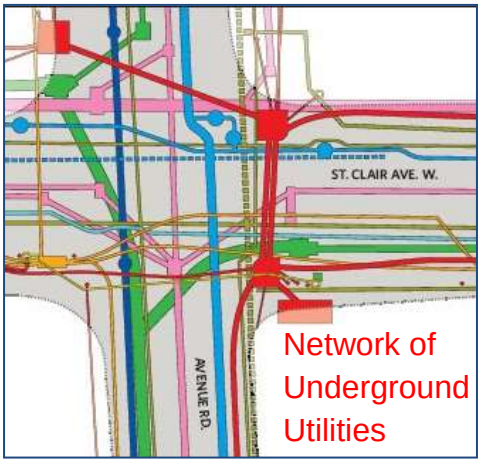
Also, the geology of the Greater Toronto area included the potential of encountering large, rocky boulders along the tunneling alignments, due to the historical glacial till geology.

The design team made sure to specify that the tunnel boring machine was capable of breaking down such big boulders. Slurry shield technology used by the tunnel boring machine provided ground stability at the cutting face and minimized ground-level disturbance and vibrations that could impact or cause damage to homes and businesses.

As a result of the careful planning and technically strong construction contract specifications, high production rates were achieved during construction, and no work stoppages occurred due to any stone obstructions.

Careful planning helped the team prepare for the unexpected.

Maintaining services



The existing underground infrastructure included a large network of utilities. These included watermain, sewers, gas lines, and telecommunications cables.

Through careful planning and coordination with numerous utility agencies during the design process, utilities were delicately relocated without any excavation using trenchless construction methods.

This careful planning prevented accidental outages or disruptions to water and utility services. A significant portion of the work also included decommissioning of the existing watermain and its connections to the existing distribution system.

Maintaining services was recognized as a major success for such a large complex project in a densely populated urban area.

An in-depth survey of all existing underground and above ground utilities, structures, and properties, was key in designing the best location for the new watermain.

Project Management & Planning

Trenchless construction holds some inherent risks. Tunnelling in a congested urban environment with a complex web of existing utilities increased the project risks. In addition, working in affluent residential and busy commercial areas, the team understood the need to mitigate impacts to residents, homes, businesses, and the public.

The project team worked closely with the City of Toronto to identify and mitigate risks and develop a communication plan. An important part of risk mitigation was developing and executing the construction staging plan, traffic management plan, and commissioning plan.

The existing watermain had to remain in operation until the appropriate connections to the new system could be made. The team developed detailed connection designs that would minimize downtime for switch-overs and decommissioning of the connections.

As well, the team addressed the issue of working in tight areas, on relatively narrow side streets with reduced access for equipment, and minimizing potential traffic disruptions.

Careful planning addressed technical, geographic, geological, economic, and social concerns to ensure client satisfaction.

Communications

The City of Toronto's public communications team and Associated Engineering's construction team coordinated with the contractor and communicated daily with concerned local residents and businesses. This significantly helped to minimize the impact on the public through all stages of construction.

The level of effort and engagement included our resident inspector taking calls on nights and weekends from residents, businesses, and concerned members of the public. The City normally undertook all public communications. However, as a result of our responsiveness, sensitivity, and commitment to reduce impacts on local residents and businesses, the City entrusted public communications to the Associated Engineering team. The effective communication during construction contributed to the project's overall success.

"Associated Engineering's Resident Inspector's excellent communications skills helped to resolve stakeholder concerns. This public relations role was extremely important to the success of this high profile project." - Jeff Flewelling, P.Eng., Senior Engineer, City of Toronto

Local media, including the Toronto Star and Toronto Sun, paid significant attention to the project, with regular articles and reports. As a result of the strong relationship between the City, Associated Engineering, and the contractor, together with the public's overall satisfaction with the project media reports and articles were positive, a benefit to the engineering and construction industry on this high profile project.

Innovation

Several types of trenchless technology, including pipe jacking, hand mining, and micro-tunneling, were used on this project. Hand mining and pipe jacking was successfully implemented in most areas with varying ground conditions which allowed the miners to have full access to the

face for removal of ground but was slow and labour intensive

For other areas with challenging dewatering conditions caused by confined aquifers or for greater impact to the surface and commuters, a closed face Micro-tunneling system was proposed that required no personnel entry.

The appropriate trenchless technology was selected after carefully examining the depth of excavation required, the soil conditions, and the groundwater at various locations where the new watermain would be installed.

The design team also evaluated the physical heavy equipment to be used. This was to ensure accurate steering control by operators and the required precise orientation to the planned underground tunneling alignment.

Micro-tunnelling

The team's prudent management of the trenchless technology employed contributed to the success of the construction phase of the project.

Social & Economic Benefits

The Avenue Road Watermain project resulted in the successful replacement of a 100-year old watermain and the construction of a new watermain.

In total, almost six kilometres of watermain was installed in a congested urban environment in an affluent residential neighbourhood. Impressively, the project team minimized any negative impact to commuters, businesses, and local residents.

The new watermain safeguards drinking water for a growing populace and reduces risks to supply.

Minimizing Disturbances

Employing trenchless construction techniques helped to avoid disturbances to private property, and protected cultural heritage sites, and tree-lined streets.

The impact on local businesses was minimized by keeping the traffic flow open.

This helped to maintain access to businesses and public buildings throughout the construction period.

Environmental Benefits

Environmental benefits were also attained, as using trenchless technologies reduced the volume of excavated material and, subsequently, the material transported away from the construction site.

Tunnelling also reduced the equipment and machinery required, thus lowering the level of dust, noise, and pollution from construction vehicles and the work itself.

Reducing the excavated material to be transported off-site minimized the truck-related air pollution.

Meeting Client's Needs

Employing trenchless technologies for this project allowed much of the construction to take place below grade, thus minimizing the impact on commuters and users of the busy Avenue Road corridor.

Micro-tunnelling was recognized as the ideal methodology given the complexity of utilities buried underground in the area, and the limited working space to store and move heavy equipment, as well as to carry out the actual construction.

The Avenue Road Watermain was one of the City of Toronto's largest and most complex projects. Traversing an urban area and incorporating both open cut and trenchless construction techniques, the project had significant risks and communication challenges for the project team to maintain positive relationships with local businesses and residents. The project held up to intense media scrutiny from local newspapers, including the Toronto Star and Toronto Sun.

The $55 million project was delivered on schedule and on budget in September 2012, exceeding the City's expectation—a credit to the technical and project management excellence of the project team.

The Avenue Road Watermain project was delivered on schedule and on budget providing safe drinking water to the City for years to come.

Conclusion

The City of Toronto's Avenue Road Watermain project increases security of water supply to the City and York Region and improves system hydraulic performance. The new watermain sustains the water supply and allows for the area's future population and economic growth.

The project exemplifies how challenging infrastructure projects can be delivered in dense urban environments while minimizing impacts to homeowners, businesses, commuters, and the general public.

A testament of the project's technical excellence, the Avenue Road Watermain Project was featured in industry publications including the Trenchless International. Recognized locally, the project received an award of excellence from the Consulting Engineers of Ontario.

This complex project demonstrates how vital infrastructure can be replaced in busy urban areas, while minimizing impact to the public.