Ten Years of Edmonton's North East Roads Program

Marlis Foth, P.Eng., M.Sc., Director Open Space Planning and Design, City of Edmonton
Hugh Donovan P.Eng., Supervisor Research & Development, City of Edmonton

Paper prepared for presentation
at the Innovations in Pavement Management, Engineering and Technologies Session.

At the 2017 conference of the
Transportation Association of Canada
St. John's, NL

ABSTRACT

In 1999 roadways in four north east Edmonton neighbourhoods began to show significant structural failures earlier than expected. As a result of continued roadway failures a study was carried out by the City of Edmonton Geotechnical Section of Engineering Services in August 2002 to identify the issue and its extent. The original study and a successive study carried out by Golder Associates in 2005 revealed that water was softening the subgrade soils causing these failures to occur. The issues include subgrade soils that were susceptible to water softening, additional surface drainage from private sump pumps and poor subgrade drainage.

With this information, the City developed several options for remediation of the failed roadways as well as to reduce the availability of water to the subgrade soils. The plan chosen involved full reconstruction of the roadway and installation of edge (periphery) drains. The new roadway cross section consisted of, non-woven geotextile, installation of 200mm diameter perforated PVC lateral drains along curbs on both sides of the road connected to the stormwater system, recycled 63mm granular base, geogrid, virgin granular base course and asphalt concrete. In 2006 the first project with sub-drains was constructed and consisted of approximately 550m of roadway with a cost of approximately $1.5 million.

Over the past ten years the treatment plan has shown to be working to address the issues and the City currently has two annual contracts each completing approximately 1,300 to 1,400m of roadway reconstruction at a cost of approximately $3.0 million dollars per year. In the past ten years the City has completed approximately 14 km of roadways within the neighbourhoods that were part of the original study and has locations for the next three years in place. Many construction techniques have been learned including how to work around utilities, development of drain wells and maintaining access for residents.

Late 2016 additional neighbourhoods were starting to show distresses similar to those reviewed in the study. As such, in 2017 neighbourhoods outside of the original study area will be reconstructed and others that are starting to show earlier signs of similar failures will be monitored regularly through visual inspections and structural testing.

INTRODUCTION

When a number of neighbourhoods in north east Edmonton were beginning to show early structural failures, the City took action to determine what was causing the premature failure and how it should be addressed. Following an internal geotechnical investigation, the City of Edmonton engaged Golder Associates Ltd. (Golder) to carry out a more detailed hydro-geological investigation into the observed failures. Based on the results of both studies and past experience, a rehabilitation procedure was developed by the City which included removal and replacement of the soft subgrade soils, installation of sub-drains connected to the storm sewer system and installation of a standard road section. This procedure is still being utilized today in the ongoing rehabilitation of the affected roadways. To address the problem the City created the North East Roads Program to proactively deal with the ongoing issue. This program has been found to be successful and it has now been in place for ten years.

BACKGROUND

In 1999 roadways in four north east Edmonton neighbourhoods began to show significant structural failures earlier than expected. These roadways continued to deteriorate and in August of 2002 the City of Edmonton Geotechnical section of Engineering Services carried out a study to determine the extent and reason for these earlier than expected structural failures. In August 2003 City Council inquired about the issues arising in this area of the City and asked for details such as: were the conditions present at the time of development, is there evidence that the water table has changed since development, what is the extent of the issue and who will pay for the cost? After the initial investigation, answers to these questions were presented to council in a report. After review of the report, council requested further information and Golder was engaged to further study this area.

Photos of the types of failures observed are included in Figure 1 to Figure 5. Figures 1 and Figure 2 show settlement and water ponding in the wheel path. Figure 3 shows a typical structural failure observed in these neighbourhoods. Figure 4 shows typical water staining from private sump pump discharge to the sidewalk and finally, Figure 5 shows asphalt failures from a point type loading of the pavement. In looking at these photos one can see the ponding/standing water and failures which can be indicative of a soft and saturated subgrade layer. Also observed was significant sidewalk staining which is indicative of overland flow of water which was traced back to the residential sump discharge or discharge of roof leader systems.

INVESTIGATION

The study completed by Golder reviewed reports of the pre-development conditions, aerial photos and sump pump discharge details. From the information that was collected and analyzed, a drilling and testing program was developed to review the existing conditions. The pre-development boreholes show the groundwater elevation was 1 to 3 m below the surface. The pre-development aerial photos of the study area show that the area was observed to be generally flat with a number of sloughs and swamps as well as seasonally waterlogged areas. The testing conducted through the drilling program included water content, plasticity index and grain size distribution. Golder performed a hydrological analysis of the potential movement of groundwater within the study area. This analysis indicated a downward movement of the groundwater indicating that the observed softening was as a result of surficial water moving downward into the subsoils rather than groundwater moving upwards into the subsoils. The findings in the Golder report concluded that the softening of the subgrade soil is directly related to the available water from the roof leaders and sump discharge penetrating into the subgrade soils under the roadway and through time weakening these soils to a point where they no longer provide support for the road structure and traffic loading.

The water softening of soils is defined as the reduction in strength due to an increase of water content. To have water softening of soils three physical conditions must exists. The confining stress must be sufficiently low to allow the soils to swell, the soil mineralogy of soils must be susceptible to water and water must be present. The study found that there were four contributing factors to the softening of the subgrade in these areas. These are the presence of softening susceptible soils, the age of the development, sump pump discharge from homes to the surface and poor drainage of the subgrade.

The recommendations from the report were to install edge drains beneath the reconstructed roads, installation of interceptor drains to avoid overland water flow into the subgrade, connection of adjacent sump pumps to the drainage system or a combination of these recommendations (Golder 2005).

CONDITION RATINGS

The City of Edmonton utilizes the Municipal Pavement Management Application (MPMA) to collect data from the roadway network to produce a condition rating of an individual roadway within our network. This rating system is known as the Pavement Quality Index (PQI). The PQI index is made up of various components including but not limited to the Structural Adequacy Index (SAI), Visual Condition Index (VCI) and Riding Comfort Index (RCI). This index is calculated and is measured on a scale of 1 through 10 with 10 being “Excellent” and 1 being “Poor”. An example of the use of the PQI is in the arterial road network where a roadway with a PQI value of less than 4 is considered in need of rehabilitation. In neighbourhood and local roadways the VCI is utilized in the determination of whether a roadway needs to be rehabilitated. A VCI of less than 4 out of 10 is the trigger value that that a neighbourhood/local roadway is in need of rehabilitation.

The roadways within the study area had VCI values ranging from a high of 4 to a low of 1.9, averaging 2.3. Typically deflection testing of local roadways is not done as a standard practice. In the case of the roadways within the north east study area it was decided, in 2002 due to the poor VCI values to perform deflection testing of the roadway utilizing the City’s Dynaflect testing system. Typical deflection values for a well performing residential roadway would be in the range of 0.025 to 0.05 mm. Upon completion of deflection testing of the four north east neighborhoods deflection values ranging from 0.1 to 0.3 mm were found which indicated a very weak pavement structure. In back calculating the subgrade modulus from this deflection testing a back calculated subgrade modulus value as low as 1.3 MPa was obtained. Normal values obtained from back calculation methods for good performing pavements would be in the range of 5-7 MPa.

RECONSTRUCTION TRIALS

Prior to 2003 any distresses that came from these areas were addressed by the City of Edmonton maintenance crews. The first trial to address these issues was completed in 2003 which was prior to the completion of the 2005 Golder study. In an attempt to reduce the amount of excavation and granular fill required to reconstruct the roadways, Cematrix, a lightweight cellular concrete was proposed to be used as a structural sub-base material. It was also intended that the Cematrix would also serve as an insulation material from frost heave and spring weakening of the existing wet subgrade soils. The proposed structure involved the excavation of the existing materials and the replacement structures as indicated in Table 1. Differing residential and collector structures were proposed based on the appropriate traffic volumes. The collector structure had an additional 60 mm of asphalt and an additional 50mm of 3-63 recycled base. Wick drains were proposed under the Cematrix at the periphery adjacent to the curb and gutter. Figure 6 shows the Cematrix sub-base installed. After the Cematrix was placed a rain event occurred and the water migrated under the Cematrix causing it to be pushed up and it began to float. This can be seen in Figure 7. The Cematrix was removed and replaced with the standard granular structure developed for the area and has had no issues since the work was performed.

In 2004 just as the report for further investigation was starting another small trial was completed which involved the reconstruction of a section of road with a similar section to what ultimately became the reconstruction standard for these areas without the use of the sub-drain system that was ultimately adopted.

In 2005 no work was carried out and the report from Golder was completed. The City also took this opportunity to perform additional deflection testing on additional suspect roadways as well as roadways where testing had been carried out in 2002 to quantify the speed at which the roadways were deteriorating. This additional testing indicated that roadways within the study area were deteriorating faster than expected and those that were considered marginally good in 2002 were now rated as being in poor condition in 2005.

After the report was completed, it was determined that rehabilitation of the affected roadways would consist of installation of 200 mm diameter sub-drains connected to the stormwater system along the periphery of the roadway on both sides, removal of the softened subgrade soils to a depth of approximately 800 mm (determined in the field), placement of nonwoven geotextile, 3-63 granular sub-base layer of varying depths with a layer of geogrid at approximately 300 mm up from the bottom of the fill, a 150 mm layer of 3-20 granular base followed by 100 mm of 10mm-LT asphalt (local roadways) and 50 mm of 10mm-HT asphalt and 100 mm of 20mm-B asphalt (for collector roadways). A typical cross section for residential and collector roadways were developed. These cross sections are shown in Figure 8 and Figure 9. The work completed in 2006 consisted of the replacement of approximately 550 m of roadway and installation of sub-drains for a cost of $1.5 million. These developed structures that were proposed in 2006 are still being utilized in current rehabilitation projects in the North East Roadway Program.

In 2009 another trial was undertaken with the use of Ureteck (Urethane foam) as a backfill material to replace some of the 3-63 granular sub-base. Figure 10 shows the Ureteck material that was used. The proposed structure included the excavation of 150 mm of the weak soft subgrade material, installation of the sub-drain system, placement of the non-woven geotextile, followed by placement of 150 mm of the Ureteck followed by the placement of the 150 mm of 3-20 granular base and the 100 mm of 10mm-LT asphalt. During completion of the granular base construction and prior to placement of the asphalt the section was proof rolled to ensure that the structure would be capable of carrying the paving equipment and trucks and it was found that that the overall structure was deflecting excessively. It was then decided to remove the Ureteck materials and proceed with reconstruction of this section with the standard cross section.

NERP PROGRAM

After the Golder study was complete in 2005 and a proposed structure developed in 2006 a long term plan was developed to manage the ongoing roadway failures in the north east area of Edmonton. This plan developed into the North East Roads Program also known as NERP. One year contracts were developed for 2006 to 2008 and in 2009 the first three year contract was released for 2009 to 2011.

As the roadway deterioration was escalating and roadways were starting to fail faster than they could be repaired and to accelerate the rehabilitation process and address failures, in 2012 two three year contracts were released and in 2015 two four years contracts were released to match the City's budget cycles. To minimize risk for the contractors in bidding the three or four year contracts, price increases or decreases are adjusted utilizing the Consumer Pricing Index (CPI) in addition to adjustments in unit prices based on the rack price of oil. Within the City's funding programs this work is funded through the Neighbourhood Renewal Composite.

CONSTRUCTION METHODOLOGY

The most common method for construction of the roadways is to first excavate for and install the sub-drains (Figure 11 and Figure 12), followed by the excavation of the road, installation of non-woven geotextile (Figure 13), installation of 3-63 recycled aggregate and geogrid (Figure 14 and Figure 15), installation or 3-20 granular base (Figure 16), concrete replacement as required (Figure 17) and finally asphalt paving (Figure 18). The main goal for NERP is to reconstruct the roadways component so only minor concrete repairs are completed to ensure that any surface water drainage is directed towards catch basins.

PROGRAM RESULTS

Over the past ten years the North East Roads Program has shown to be working to address the subgrade softening issues that are present. The City of Edmonton has gone back to older sections of roadways reconstructed using the chosen protocols and performed structural testing, Dynaflect and falling weight deflectometer (FWD), in an attempt to determine the effectiveness of the rehabilitation. This testing has indicated good performance the oldest sections showing deflection values of 0.025 to 0.030 mm after as long as 13 years with VCI values ranging from 8 to 10.

Each North East Roads Program contract completes approximately 1,300 to 1,400 m of roadway reconstruction with the sub-drain system installed along both roadway edges each year for an expenditure of approximately $3.0 million dollars annually per contract. In the past thirteen years since the issue was noted approximately 14 km of roadways in the original study area have been reconstructed.

LEARNED DESIGN / CONSTRUCTION TECHNIQUES

With more than ten years of dealing with the issues within north east Edmonton, various methods of treatment have been tried and evaluated. With these trials, the best method for remediation was found to include the installation of the sub-drains along the periphery to draw any excess water away from of the roadway structure. With the installation of the sub-drains along the periphery, the greatest challenges are to get around the utilities and maintain access for residents.

Getting around the utilities typically involves going above or below the utility or sometimes making a break in the sub-drains and grading the pipe in the opposite direction of road grade. Typically in cul-de-sacs, cleanout manholes are also added for maintenance reasons. All sub-drains are tied into either manholes or catch basins which then drain to the stormwater system.

Some locations have concentrated overland surface drainage where multiple lots are draining to one area. In the past this water has either crossed the sidewalk to enter into the drainage system causing stains and/or has saturated the ground and infiltrated into the roadway subgrade. To address this issue a drain well has been installed to capture the water at the back of the walk and then direct it into the sub-drain system.

The impact on residences and maintaining access can also be challenging. Most of the homes in the construction areas only have front access which means residents lose direct access to their homes and driveways. Due to emergency response requirements no more than 100 m of roadway may be closed at one time. This means that residents will lose access to their homes for two to three weeks or more. At the time these neighbourhoods were developed, standards on lengths of cul-de-sacs were different and there are numerous longer cul-de-sacs which sometimes exceed 100 m. Completing the reconstruction of half of the roadway at a time was considered but is not possible as the material is unstable and a rotational slope failure may occur which is a safety issue. As such, the full width of the roadway is constructed in 100 m sections.

In 2016 a 100 m section of roadway that had five longer cul-de-sacs attached was scheduled for reconstruction. In the worst case with one section of road being removed, 93 homes would lose access. The homes that would have been in the last construction stage would have lost access for the majority of the summer. To address these concerns an alternative access was considered. The only alternative access that was available was to change a 1.5 m wide walkway connection to a future 3.0 m emergency access and utilize it as a vehicle access with temporary traffic signal lights. See Figure 19. This allowed access to the homes that would have been cut off by construction.

FUTURE PROGRAM

Late in 2016 other areas of the City began to show similar pavement distresses and failures as those seen in the original study area. As such in 2017 the North East Roads Program will be moving further west in the north end of Edmonton. Further deflection testing and monitoring for certain areas that are showing early signs of failure will be reviewed. Once all of this information is collected, the new areas will be reviewed with the areas already planned to be reconstructed to determine which locations are of higher priority. The reconstruction of these roadways that are showing this premature failure continues to be a priority in the City. The City has approximately 10-15 years of development areas that could potentially start showing similar failures where issues may need to be addressed.

CONCLUSION

Roadways in north east Edmonton began to fail prematurely. The City contracted Golder Associates Ltd. to complete a hydro-geological investigation to determine the cause. From the study it was found that water was softening the subgrade soils which was causing the failures and issues. Contributing to this included the presence of subgrade soils that were susceptible to water softening, additional surface drainage from private sump pumps and roof leaders and there was also poor subgrade drainage.

In the early 1980's sumps were required to be connected to the sanitary sewer system in residential structures, but it was determined that if this practice continued the sanitary sewer system would eventually fail. With that in mind the public works department of the time banned the connection of the sumps to the sanitary sewer system. Now in Edmonton there are approximately 10 to 15 years of development where sumps were no longer allowed into the sanitary system and were allowed to discharge onto the property owner's lawn. This sump discharge, sometimes quite large, resulted in wet saturated lawns which home owners did not like. The solution to the problem was to connect small hoses to the end of the sump discharge and direct the water over the sidewalk into the roadway drainage network. This has seemed to fuel the majority of the observed failures. In 2009 the City of Edmonton mandated the connection of the residential sump system into the storm system through an intimate connection into the system. It is anticipated that through this action we will see a reduction of this issue in future developments.

The City of Edmonton had neighbourhood roadways in the north east of the city that were showing early signs of failure. After trials of various materials and a geotechnical investigation the North East Roads Program was developed and has found to be successful in dealing with these issue roadways over the last ten years. Through the last ten years a number of construction techniques have been learned to work around existing utilities and ensure that residents and emergency vehicles have access. This program will continue in the future as other areas within the City are starting to show similar failures.

REFERENCES

Golder Associates Ltd. 2005. Final Report Northeast Edmonton Hydrogeological Program

FIGURES

Figure 1 Settlement and water ponding in wheel path

Figure 2 Settlement and water ponding in wheel path.

Figure 3 Structural Failure

Figure 4 Water staining on sidewalk and alligator cracking on roadway.

Figure 5 Failures due to soft subgrade

Figure 6 Cematrix Sub-base

Figure 7 Cemetrix Floating after Rainfall

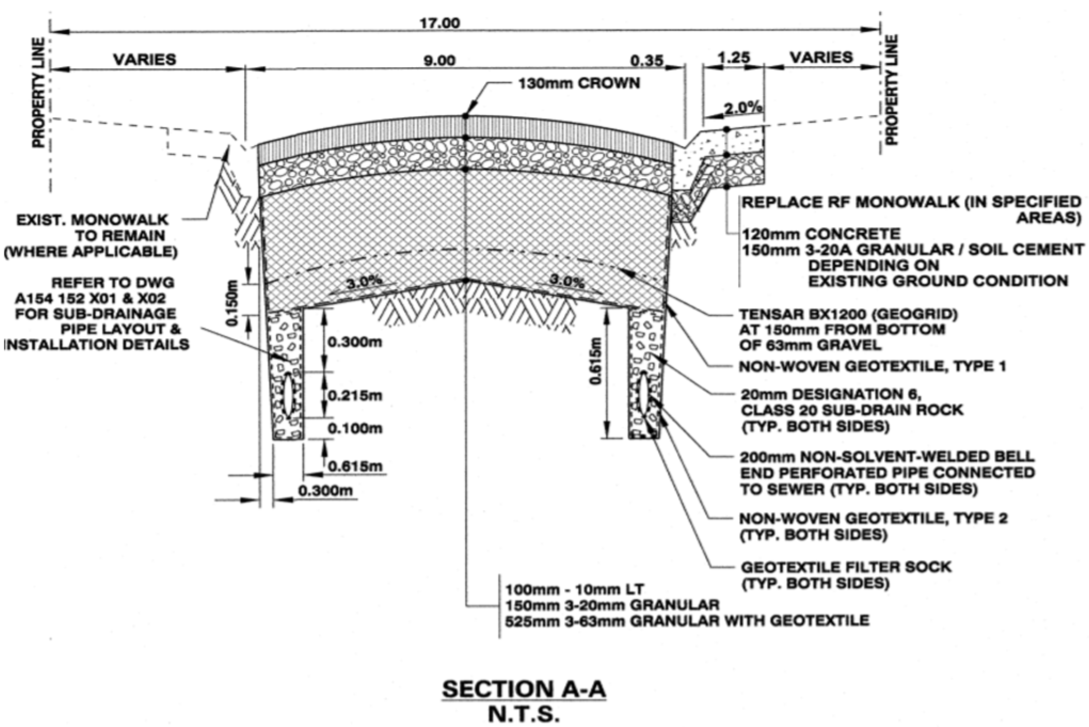

Figure 8 Typical Residential Cross Section

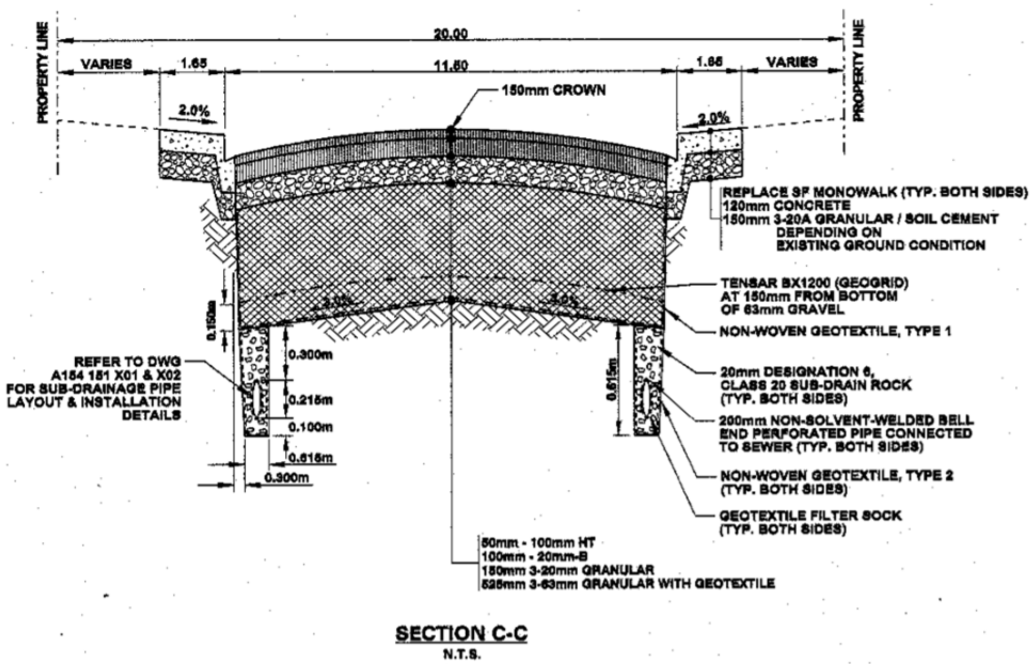

Figure 9 Typical Collector Cross Section

Figure 10 Uretek

Figure 11 Sub-drain Excavation

Figure 12 Sub-drain Installation

Figure 13 Installation Non-woven Geotextile

Figure 14 Granular Sub-base over Non-woven Geotextile

Figure 15 Geogrid Placement

Figure 16 Placing 3-20 Granular Base

Figure 17 Concrete Replacement

Figure 18 Paving

Figure 19 Temporary Signal for Access

TABLES

Table 1 2003 Cematrix Trial

Material	Residential Road (mm)	Collector Road (mm)
ACO	65	50
ACB	-	75
3-63	100	150
CMI - 475 Cellular Concrete	150	150
20mm Screened Rock	100	100
Total	415	525