# WINTER OPERATION AND MAINTENANCE OF TUNNELS IN NORTHEASTERN MINNESOTA

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## ABSTRACT

There are four examples of roadway tunnels in northeastern Minnesota that have unique issues relating to maintenance during the winter. These tunnels are located along I-35 in Duluth, Minnesota and U.S.T.H. 61 which runs from Duluth, Minnesota to Grand Portage, Minnesota along the north shore of Lake Superior. All of these tunnels are in a freshwater marine environment where the annual snowfall is approximately 80 inches. Four of the most troubling winter maintenance related issues are summarized below:

1. One of the winter maintenance issues encountered is a drainage issues encountered in the cut and cover tunnels along I-35 during spring run-off periods. The drainage issues are due to ice in the storm drains coupled with outlets that frequently plug with drift rock from Lake Superior during storm events that generally occur during the winter. The solution to this issue is frequent cleaning of the outlet structures.

2. Another issue relates to cleaning the tunnels after the winter season. All of these tunnels are lined with tiles which are designed to create a bright environment inside the tunnels. During the winter season, the tiles get covered with ice reducing chemicals and grime. Due to the proximity to Lake Superior, all cleaning products and wash water must be recovered and disposed into a treatment facility. Special procedures have been developed for completing this work in an environmentally sensitive manner.

3. A third winter maintenance issue relates to the portals of our hard rock tunnels that are located along U.S.T.H. 61. These tunnels have portals cut into hard rock. Due to the exposed face of these tunnels, the rock is weathering at a rate much greater that ever anticipated. This has resulted in seasonal rock fall occurrences which tend to be greatest in the spring as melt water freezes and thaws most frequently. We have needed to develop a rock scaling method and redesign one of our rock catchment basins to address this issue.

4. The last winter maintenance issue in these tunnels relates to the durability of electronic equipment. The tunnel environment is harsh on the doors and other appurtenances in the tunnels. The original passage doors between tunnel conduits were replaced after about 10 years of service with fiberglass fire rated doors as they were totally corroded. The fire alarm pull stations and cabinets for phones and fire extinguishers in all the tunnels have had similar issues.

## KEYWORDS

CUT AND COVER ROAD TUNNELS / WINTER OPERATION AND MAINTENANCE / DRAINAGE / PROTECTION OF FRESHWATER MARINE ENVIRONMENT / ROCK FALL

## 1. INTRODUCTION

The northern terminus of Interstate Highway 35 in Duluth, Minnesota is constructed through an urban environment along the shores of Lake Superior. The urban plan for this highway needed to accommodate this high speed roadway design in this setting. Part of the plan to accomplish this task was the construction of four cut and cover concrete tunnels, each carrying two lanes of traffic divided by a wall. The tunnels are located in a 4 km corridor. These tunnels are known as the Lake Place Tunnel (Br. 69819), the Superior Street West Tunnel (Br. 69821), the Superior Street East Tunnel (Br. 69820) and the Leif Erikson Park Tunnel (Br. 69836). These tunnels vary in length from 156.5 m to 451.1 m.

**Figure 1.** Lake Place Tunnel – Interstate 35 – Duluth, Minnesota (USA)

Minnesota Trunk Highway 61 traverses along the shoreline of Lake Superior from the northern terminus of Interstate Highway 35 for 241.4 km. This roadway was built through rugged basaltic rock terrain for most of its length. Along this path, there are two tunnels that cut through the basaltic rock outcroppings. The road was realigned from the shoreline in order to alleviate concerns about the roadway eroding into Lake Superior. These tunnels are known as the Silver Creek Cliff (Br. 38005) and Lafayette Bluff (Br. 38003) Tunnels. They are 409.6 m and 259.7 m in length respectively.

There are four examples of roadway operations issues relating to maintenance during the winter that will be presented as part of this paper. These issues all have ties to the fact that the tunnels are located in a freshwater marine environment where the annual snowfall is approximately 200 cm and temperature ranges from -40 to 34 degrees C. Typical winter maintenance in these corridors includes routine road patrols on a 24/7 basis. Winter maintenance activities also include anti-icing treatments with magnesium chloride or salt brine. Snowplowing, material application and hauling snow in areas where snow storage is limited are also normal winter maintenance activities in around and through these tunnels. Material application includes a variety of mixtures of pre-wet rock salt or treated sand. Typical pre-wetting agents are either salt brine or magnesium chloride, depending upon temperature.

## 2. STORM DRAIN OUTLET PLUGGING:

One of the maintenance issues encountered is drainage from the storm drain system of the cut and cover tunnels along Interstate 35. This issue has been most common during the spring run-off periods because the drain system has had little or no flow during the past 5 months. These tunnels are depressed in relation to the surrounding terrain to allow the city streets and parks to occur at their designed profile. This makes the highway profile just slightly above the Lake Superior water level. There is minimal fall between the depressed roadway and the storm drain outlets at the lake. There are several storm drain outlets from this system some of them are in locations susceptible to drift rock during storm events where the waves impact the shoreline. Each of these outlets was designed with an outfall at about the Lake Superior water elevation. Rock revetment was installed near the outfalls in order to create an outlet pond that would protect the outlet structure. The drainage issues are due to ice in the storm drains coupled with outlets that become plugged during winter storms with drift rock from Lake Superior. The most severe storm events generally occur during the winter. The rock revetment treatment has proven no match for forces of nature. Storms with easterly or northeasterly winds often produce waves over 3 m in height that impact the shoreline in the vicinity of the storm drain outlets. The power of these storms moves massive quantities of beach rock along the shoreline, accumulating in areas were the terrain allows the formation of natural beaches. This issue requires frequent cleaning of the outlet structures. The indicator of need for this cleaning has been water backing up at the storm drain catch basins along the entire corridor during spring run off.

Several methods have been employed by our maintenance forces to maintain the drainage of this system. In some cases, the head pressure from the water standing on the roadway and in the drainage system can be employed to allow the system to flush itself out. The maintenance employees used hand tools to locate the top of the pipe and shovel out some of the drift rock. Once the water begins to run at a trickle, it may begin to flush the pipe outlet out. If this method fails, an excavator has been used to remove drift rock from outlet pond, which also allows the system to flush itself out. The method that has the highest risk is to use the fire suppression system to flood the storm drains. Fire hoses have been inserted into the storm drain manholes, creating enough head pressure to flush the system. Since there is risk that this method may cause more problems than it solves, the maintenance employees are more dependent on allowing the water to back up during a rain event and be aware that the rain is an opportunity to work at the outlets to make sure that they are clean.

Any rock that has been excavated has needed to be hauled away due to the fact that it becomes coated with grease and oil from the storm drain system. The drift rock, at the outlet, acts as a filter for any water that flows through the system.

At one of the outlets, the maintenance crew designed a grate system to prevent material from entering the outlet. This grate system is made to accommodate a high lift jack to remove the grates once they become clogged with debris from inside the storm drains. During summer periods, the grate will be temporarily removed and the debris will be allowed to clean out of the inside of the system by rain events.

## 3. TUNNEL WASHING

Another issue relates to cleaning all six tunnels after the winter season. All of these tunnels are lined with tiles which are designed to create a bright environment inside the tunnels. During the winter season, the tiles get covered with ice reducing chemicals and grime. These walls are washed on an annual basis each spring. The work is performed during a night time operations to minimize traffic disruption.

Due to the proximity to Lake Superior, all cleaning products and wash water must be recovered and disposed into a treatment facility. Special procedures have been developed for completing this work in an environmentally sensitive manner. The washing process involves using a specialized tunnel washing device that has a rotary brush and water supply. Additionally, a water tanker truck with spray nozzles is employed to prewet and rinse the walls. Difficult grime and locations that cannot be cleaned with the tunnel washing truck, such as near the man doors and along the concrete traffic barriers, are cleaned by hand scrubbing with long handled brushes. All wash water is trapped on the road surface by covering the storm drains with water resistant mats. Additionally, the maintenance employees have employed sediment filter pads that are installed inside the catch basins to ensure that water escaping this procedure has sediment removed before it reaches Lake Superior. The cleaning agent used is a “green” soap product to reduce the environmental impact of any material that escapes this process. A vacuum truck is used to remove the dirty wash water from the road surface and dispose of the water at the sanitary sewage treatment plant. Testing of any water that has escaped this process at the storm drain outlets has been completed to ensure that hazardous materials are not present. Testing has shown that there are not measurable levels of regulated contaminants in the residual drainage that reaches Lake Superior.

## 4. HARD ROCK PORTAL MAINTENANCE

A third winter maintenance issue relates to the portals of the hard rock tunnels that are located along T.H. 61. The Silver Creek Cliff Tunnel has portals cut into hard rock (Figure 2). The resulting faces of the tunnel portals have vertical rock faces up to 120 m high that run parallel and perpendicular to the roadway. Below these rock faces, are engineered rock catchments ditches that were designed to trap any falling rock and debris from the portal faces and prevent the falling rock from bouncing or landing on the roadway. The rock catchments ditches were designed to include a width of up to 12 m wide, and a depth varying from 1.2 m to 2.4 m. The dimensions vary depending upon the height of the adjacent rock face. All of these rock catchments ditches have a concrete traffic barrier located between the roadway surface and the ditch (Figure 2).


**Figure 2.** Rock Fall debris at Silver Creek Cliff Tunnel on Minnesota Trunk Highway

The exposed rock face of these tunnel portals is weathering at a rate much greater than anticipated. This has resulted in seasonal rock fall occurrences which tend to be greatest in the spring as melt water freezes and thaws more frequently. These rock fall occurrences also seem to be accelerated during rainy periods. Some of these rock fall occurrences have been small. Resulting rock fall varies from a few small rocks to piles of up to a few cubic meters. More recently, the rock falls have become larger, resulting in the catchment ditches becoming filled and some rock bounding off the resulting rock pile in the ditch and onto the roadway. This is not an acceptable condition due to the impact that rock falling or laying on the roadway could have on traffic safety. The initial rock falls have been addressed by taking immediate action to clean the rock catchments area. As the problem has become more severe at the south portal, it was determined that the rock catchments area was not of adequate size and that the portal face has weathered to the extent that additional techniques would be needed to remove rock in a controlled manner rather than allowing it to fall under the forces of mother nature.

A process was developed to map the weathered areas and identify those that were most in need of removal by our staff geologists. The geologists determined that some of the failure planes in the rock face created conditions where masses of rock were susceptible to failure. A contract was let to scale these areas. A variety of techniques were discussed and employed. Due to difficulty in access to the nearly vertical rock face, hand scaling is not a feasible option. The initial scaling attempt consisted of drilling and blasting. Access for drilling required that workers access the rock face from a man basket lifted by a hydraulic crane. Drilling for placement of the blast charges was accomplished using handheld drills. This method proved to be very time consuming and inefficient. The workers were subject to the danger of disturbed material falling on them while they were drilling holes for the next charge.

Another method was employed using a mobile crane with a cable lift assembly and wrecking ball to mechanically remove the hazardous rock outcroppings up to 30 m high. This method was found to be very efficient due to the fact that any material that was not solid could be removed within a few impacts with the wrecking ball. This method also allowed all workers to be out of harms way during the removal process.

The next step in this process was to completely clean out the rock catchment area to ensure that it had the maximum capacity available. The rock catchment ditch area was increased by creating a 2 m high wall made of rock-filled gabion baskets on the back side of the concrete traffic barrier to increase the depth of the catchment ditch. The permanent solution will be to replace the concrete traffic barrier with a structural wall that is 2 m high and has a sacrificial timber back to prevent damage to the concrete from falling rock.

## 5. MECHANICAL EQUIPMENT

The last maintenance issue in these tunnels relates to the durability of electronic and mechanical equipment and hardware. The tunnel environment is harsh due to the use of the winter anti-icing chemicals, and a continuous cool, moist environment. Within the first 10 years of operation, several components of the electronic and mechanical equipment and hardware were found to be susceptible to corrosion due to this environment.

There are fire rated man doors through the tunnel wall on the Interstate 35 tunnels. In these tunnels, the doors, door frames, and hardware were painted steel and the materials corroded beyond serviceability within 10 years and needed to be replaced. The replacement doors were made with fibreglass reinforced plastic resin materials tailored to a specific corrosion environment. The door frames were 100% fibreglass material. Hardware and locksets were stainless steel. The replacement materials have been in place for the past 11 years with no deterioration.

The fire alarm pull stations and cabinets for phones and fire extinguishers in all the tunnels have had similar issues. Many of these components were originally metallic composition and replacement materials were fibreglass or plastic based as much as possible. Electrical contacts were corroded in locations that corrosive vapours had access to the connections. These connections were replaced with components designed with anti-corrosion grease inside the connection.

Electrical junction box cover screws were originally galvanized cast steel. These screws corroded to the point that they could not be removed with out destructive means. They were replaced with stainless screws and coated with lubricant compound which seems to have a longer service life and better protective properties.

## 6. SUMMARY

Tunnel construction is often necessitated by the challenge of providing transportation facilities in complex environments. Some of these maintenance lessons learned can be helpful reminders that operational needs must be thoroughly considered in the design process. Many operational issues are hard to imagine during the design phase such as the accelerated rock face weathering. In other cases, the issues have been considered and addressed unsuccessfully. Regardless of the case, the roadway authority must be resourceful in providing a safe, reliable facility for the travelling public.