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## Municipal Roads Repaired with TDA in Manitoba



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## **Nomenclature**

**TDA** Tire Derived Aggregate

**PLT** Passenger Light Truck

**RTR** Reliable Tire Recycling

**OTR** Off The Road Recycling

**RM** Rural Municipalities

**L** Length

**W** Width

**H** Height

**V** Volume

**A** Area

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## **Introduction**

Manitobans generated 19,414 tonnes of new tires and the scrap tire program operated by Tire Stewardship Manitoba (TSM) recovered 15,636 tonnes of scrap tires in 2014.[1] Tire Derived Aggregate (TDA) represents 64% of total tonnes of material recovered. TDA is beneficial to Manitoba because of its ability to handle our cold climate. Also its permeability makes it a feasible alternative to earthen aggregate in high water table applications. TDA was used as lightweight fill for reconstruction of eight municipal roads in Manitoba. Two recycling companies from the Province were involved in these projects. The companies are Reliable Tire Recycling and OTR Recycling.

## **Geology of Manitoba**

The Pleistocene Epoch is often referred to as the Ice Age since continental ice sheets spread across Canada during this time. The effects of these glaciations profoundly influenced Manitoba's topography. Manitoba's landscape currently bears the legacy of these late Pleistocene glaciations which eroded and reshaped the land surface. Esker complexes such as Birds Hill; moraines like The Pas, Sandilands and Tiger Hills; and the Pembina, Souris and Assiniboine Valley are just a few of the numerous consequences of glaciation. Meltwater lakes, in particular Lake Agassiz, are another result of glaciation and have also influenced the shape of Manitoba's landscape.

Manitoba occupies an area of 650,000 km<sup>2</sup>. About 10,000 years ago Lake Agassiz covered 350,000 km<sup>2</sup>. The water was more than 200 meters deep at Winnipeg. When the ice sheets had retreated as far north as the mouth of the Nelson River approximately 5,000 years ago, access to the open sea became available. This resulted in a sudden drainage of the remaining part of Lake Agassiz, which left behind the ancestral forms of Lake Winnipeg, Lake Manitoba and Lake Winnipegosis. Deposits of silt and clay that were left on the lake bottom cover a large portion of the province today.[2]

## **Frost heaving**

One of the most common and costly problems for municipal roads in Manitoba is frost heaving. Frost heaving (or a frost heave) is an upwards swelling of soil during freezing conditions caused by an increasing presence of ice as it grows towards the surface, upwards from the depth in the soil where freezing temperatures have penetrated into the soil (the freezing front or freezing boundary). Ice growth requires a water supply that delivers water to the freezing front via capillary action in certain soils. The weight of overlying soil restrains vertical growth of the ice and can promote the formation of lens-shaped areas of ice within the soil. Yet the force of one or more growing ice lenses is sufficient to lift a layer of soil, as much as 30 cm or more. The soil through which water

passes to feed the formation of ice lenses must be sufficiently porous to allow capillary action, yet not as porous as to break capillary continuity. Such soil is referred to as "frost susceptible." The growth of ice lenses continually consumes the rising water at the freezing front. Differential frost heaving can crack pavements—contributing to springtime pothole formation—and damage building foundations. [3]

## **Tire Derived Aggregate – Properties**

Tire shreds that comprise TDA have several special properties that civil engineers can use to solve difficult design situations. The most important property is that tire shreds are lightweight. The in-place unit weight of tire shreds is between 45 and 58 pcf – even after they have been compressed under the weight of overlying fill. For comparison, soil fill typically weighs 125 pcf. This makes tire shreds an excellent lightweight fill material.

Civil engineers need lightweight fill to improve the stability of embankments built on weak soils and to help stabilize landslides. Tire shreds also produce a low horizontal stress and they are compressible. Thus, when they are used as fill behind walls, they produce lower horizontal pressure on the back side of the wall. This allows civil engineers to design thinner, cheaper walls.

Tire shreds are very free draining. Even when they are compressed under the weight of overlying fill, they still have permeability greater than 1 cm/sec. With permeability this high, tire chips can be used as drainage layers in landfills and roads. A useful property of tire shreds is that they have a high insulating value. The thermal conductivity of tire shreds with a 3-in. maximum size is about 0.14 Btu/hr-ft-°F. This is seven times better than soil, which typically has a thermal conductivity of about 1 Btu/hr-ft-°F. When combined with their good drainage properties, this means that tire shreds can be used to limit frost penetration beneath roads and to remove excess water during the spring thaw.

Due to the special properties of tire shreds together with their wide-spread availability, they have been used as lightweight fill for numerous highway embankments and landslide stabilization projects, backfill behind bridge abutments, insulation and drainage layers beneath roads, and drainage layers in landfill liners and caps. [4]

## **Tire Derived Aggregate – Types**

There are two types of TDA: Type A with a maximum size of 3 in. (75 mm) and Type B with a maximum size of 12 in. (305 mm). While these are the most commonly used sizes, TDA specifications are determined by the end use and will differ based on the contractor's technical, environmental and economic requirements for the project. TDA has become the commonly accepted description for this material because it better conveys the intrinsic engineering value of size-reduced scrap tire pieces as compared to the term tire chip or tire shred. [5]

Type B is the most common type used in roads embankments in Manitoba. The reasons TDA Type B works so well in preventing and repairing "frost heave" are:

- (1) It prevents the wicking action that brings moisture into the road bed where it can form a "frost lens."
- (2) It has 8 times the insulation value of mineral aggregate reducing frost penetration into the road bed and subgrade.
- (3) It is light weight and interlocking which helps stabilize soils that have low load-bearing properties.

## **Projects in Manitoba**

Manitoba's Municipal Road Projects in chronological order are:

- 1998 – 1999 – La Broquerie Road
- 1999 – 2000 – Garven Road

RM of Siglunes

- 2009 – Silver Bay Road
- 2009 – 2010 – Cook Road

RM of Hamiota

- 2013 – 2014 – Municipal Road 136W between 78 & 79N
- 2013 – 2014 – Municipal Road 87N between 137 & 138W
- 2013 – 2014 – Municipal Road 80N between 135 & 136W

In the former Town of Hamiota

- 2013 – 2014 – 4th Street between Spruce Avenue and Ash Avenue

## Projects Reconstructed by Reliable Tire Recycling

### La Broquerie Road – 1998 – 1999

The road is an all-weather access road to a Hutterite Colony near La Broquerie, and it was the first road made with TDA in Manitoba by Reliable Tire Recycling. The length of the road is 1600 m, but just half of it was reconstructed (800m). The width of the road is 8m and conforms to Basic Design Standards in Manitoba – 1986. The road embankment was excavated 0.91m and the tire shreds 0.15m nominal were hauled to the site and spread with a backhoe. The thickness of the tire shreds is 0.76m. The tire shreds were compacted in layers with five passes of a bulldozer and covered with 0.6 m clay base, with gravel on top.

$L=800\text{m}$ ;  $H=0.76\text{m}$ ;  $W=8\text{m}$ .

$V=L*H*W= 4,864\text{m}^3$ ;  $1 \text{ m}^3 = 55 \text{ PLT scrap tires}$

Average weight of PLT scrap tire= $10.51\text{kg}$

$1 \text{ m}^3 = 55*10.51=578.05 \text{ kg}$ ;  $578.05 \text{ kg}*4,864\text{m}^3 = 2,811,635.2 \text{ kg} = 2,812 \text{ tonnes}$

A total of 2,812 tonnes of tire shreds were used for this project, the equivalent of 267,520 PLT scrap tires.



Figure 1. Road section reconstructed with TDA near La Broquerie, Manitoba

Photo: Ashley Leibl



*Figure 2. Differences between the initial road and reconstructed one, near La Broquerie, Manitoba  
Photo: Ashley Leibl*

### **Garven Road – 1999 – 2000**

The project site is located 5 km north-east of Winnipeg, Manitoba, Canada, near the intersection of PR 213 and 206. The site is a 300m private access road to an active gravel pit. The site is mostly a boggy area with an influx of surface water flowing from a neighboring golf course. The subgrade in this area is very soft and excessive settlement is expected if conventional fill and surface materials are used.

A soil investigation was carried out by the University of Manitoba to assess the subgrade conditions of the site. The study showed that the soil stratigraphy consisted of about 0.2 – 0.3m of black organic topsoil underlain by plastic clay. The topsoil was wet and sandy with some soft grey clay intermixed. The residual soil was mostly brown clay with fine sand, silt lenses, and silt nodules. The high plasticity clay ranged from soft near the surface to firm at a depth of 3.0 m. Ground water was found to be at or very near to the existing ground surface indicating a high water table and poor drainage conditions.

The road embankment was constructed in July 1999. Initially, five layers of the whole tire sidewalls were manually placed on the subgrade in an overlapping pattern to provide a clear working surface and to raise tire shreds above the ground water table. Tire sidewalls are not processed by a shredder and, therefore, have an insignificant amount of exposed steel.

The tire shreds were hauled to the site, unloaded directly over the sidewalls, and spread to the desired thickness of 1500mm (1.5m) with a backhoe. The tire shreds were compacted in layers with five passes of a bulldozer. A gravel surface layer with a thickness of 450mm (0.4m) was placed over the tires. [6]

$L=300\text{m}; H=1.5\text{m}; W=8\text{m}.$

$V=L*H*W= 3,600\text{m}^3; 1 \text{ m}^3 = 55 \text{ PLT scrap tires}$

Average weight of PLT scrap tire=10.51kg

$1 \text{ m}^3 = 55*10.51=578.05 \text{ kg}; 578.05 \text{ kg}*3,600\text{m}^3 = 2,080,980 \text{ kg} = 2,081 \text{ tonnes}$

$A= L*W=2400\text{m}^2; 1 \text{ m}^2 = 2 \text{ sidewalls}; \text{Total sidewalls}= 2,400*2*2=9,600$

A total of 2,081 tonnes of tire shreds were used for this project, the equivalent of 198,000 PLT scrap tires.



Figure 3. Construction of the tire shred embankment, Garven Road, Manitoba

Photo: Ashley Leibl



Figure 4. Construction of the tire shred embankment, Garven Road, Manitoba

Photo: Ashley Leibl

## **Project Reconstructed by OTR Recycling**

### **Rural Municipality of Siglunes**

The climate in the area can be related to weather data from Ashern located in the northern part of the municipality. The mean annual temperature is 1.1/C and the mean annual precipitation is 483 mm (Environment Canada, 1993). The average frost-free period is 82 days and degree-days above 5/C accumulated from May to September average 1527 (Environment Canada, 1982). Physiographically, the municipality is located entirely in the Interlake Plain section of the Manitoba Plain (Canada-Manitoba Soil Survey, 1980). The terrain surrounding Dog Lake is very flat and poorly drained and characterized by marsh and saline mineral soils. As a result of the gently sloping land surface and the ridge and swale relief pattern throughout the municipality, the majority of soils are imperfectly to poorly drained. The municipality is characterized by high groundwater levels. [7] There are two sections of gravel road reconstructed with TDA located in the Rural Municipality of Siglunes, Manitoba.

### **Silver Bay Road – 2009**

The project site is located 3.2 km north of Ashern, Manitoba, between N40 Road and MB-6 and it was the first municipal road project constructed by OTR. The construction occurred in 2009. The length of the road is 75m and the width is 8m (Basic Design Standards in Manitoba – 1986). The underlying soil has poor load bearing properties, is silt and most often is affected by a ground high water table or has surface water on one or two sides of the road. The road embankment was excavated one meter and TDA thickness is usually between 0.40-0.60 meters, but the road constructor preferred 0.60 meters instead of 0.40 meters. The TDA layer was placed under compression with 6 passes of D 6 Cat or similar size track hoe. TDA used for this project was Type B. The layer on top of TDA was 0.63 meters of compacted road building material, and the road was covered with a thick layer of gravel.

$L = 75\text{m}; H = 0.6\text{m}; W = 8\text{m};$

$V = L * H * W = 75 * 0.6 * 8 = 360\text{m}^3 = 470.86\text{yd}^3$

$\text{Yd}^3 = 376\text{kg};$  average weight ORT scrap tire = 324.64kg

$470.86 * 376 = 177,043.36\text{kg} = 177 \text{ tonnes}; 177,043.36\text{kg} / 324.64\text{kg} = 545 \text{ OTR tires}$

A total of 177 tonnes of tire shreds were used for this project, the equivalent of 545 OTR tires.

### **Cook Road –2009 – 2010**

The project site is located 4km from Ashern, Manitoba between Prov. Highway 325 and Glencora Road. The length of the road is 200 m and the width is 8m (Basic Design Standards in Manitoba -1986). The construction occurred in 2009 – 2010. The underlying soil has poor load bearing properties, is silt and most often is affected by a ground high water table or has surface water on one or two sides of the road.

The road embankment was excavated one meter and TDA thickness is usually between 0.40-0.60 meters, but the constructor preferred 0.60 meters instead of 0.40 meters. The TDA layer was placed under compression with 6 passes of D 6 Cat or similar size track hoe. TDA used for this project was Type B. The layer on top of the TDA was 0.63 meters of compacted road building material, and the road was covered with a thick layer of gravel.

L= 200m; H= 0.6m; W= 8m;

$V = L * H * W = 200 * 0.6 * 8 = 960 \text{m}^3 = 1,255.6 \text{yd}^3$

$\text{Yd}^3 = 376 \text{kg}$ ; average weight OTR tire = 324.64kg;

$1255.6 * 376 = 472,105.6 \text{kg} = 472 \text{tonnes}$ ;  $472,105.6 \text{kg} / 324.64 \text{kg} = 1,454 \text{OTR tires}$

A total of 472 tonnes of tire shreds were used for this project, the equivalent of 1,454 OTR tires.

## Rural Municipality of Hamiota

There are three sections of gravel road reconstructed with TDA located in the Rural Municipality of Hamiota, Manitoba. One large section is north of Hamiota and the other two sections are southeast of the town. All of the sections are in low elevation areas where the roadway cuts through a marsh. These areas have been and continue to be a nuisance and an extra expense to the RM. Every spring the melting snow floods many of the roads in the area, and the RM has to transport in more earthen aggregate to the sites.



Figure 5. Example of frost boils in Hamiota

Photo: Peter Schroedter



Figure 6. Example of repair site in Hamiota

Photo: Peter Schroedter

### **Municipal Road 136W between 78 & 79N – 2013 – 2014**

The project site is located in the area of the RM of Hamiota, Manitoba, between 78 & 79N and the construction period took place in the summers of 2013 and 2014. The length of the road is 200m and the width is 8m (Basic Design Standards in Manitoba - 1986). The underlying soil is silt, has poor load bearing properties and most often is affected by a ground high water table or has surface water on one or two sides of the road.

The road embankment was excavated one meter and TDA thickness is usually between 0.40-0.60 meters, but constructor preferred 0.60 meters instead of 0.40 meters. TDA layer was placed under compression with 6 passes of D 6 Cat or similar size track hoe. TDA used for this project was Type B. The layer on top of TDA was 0.63 of compacted road building material, and the road was covered with a thick layer of gravel. L= 200m; L= 200m; H= 0.6m; W= 8m;

$$V = L * H * W = 200 * 0.6 * 8 = 960 \text{m}^3 = 1,255.6 \text{yd}^3$$

$$\text{Yd}^3 = 376 \text{kg}; \text{ average weight ORT tire} = 324.64 \text{kg}; 24 \text{inch} = 0.6 \text{m}$$

$$1255.6 * 376 = 472,105.6 \text{kg} = 472 \text{ tonnes}; 472,105.6 \text{kg} / 324.64 \text{kg} = 1,454 \text{ OTR tires}$$

A total of 472 tonnes of tire shreds were used for this project, the equivalent of 1,454 OTR tires.



Figure 7. Zoom of road section North of Hamiota (Google, 2014)

### **Municipal Road 87N between 137 & 138W – 2013 – 2014**

The project site is located in the area of the RM of Hamiota, Manitoba, between 137 & 138W and the construction period took place in the summers of 2013 and 2014. The length of the road is 300m and the width is 8m (Basic Design Standards in Manitoba - 1986). The underlying soil is silt, has poor load bearing properties and most often is affected by a ground high water table or has surface water on two sides of the road.

The road embankment was excavated and one meter and 0.60 meters of TDA layer was placed under compression with 6 passes of D 6 Cat or similar size track hoe. The TDA used for this project was Type B. 0.63 meters of compacted road building material was placed on top of the TDA, and the road was covered with a thick layer of gravel.

$L = 300\text{m}; H = 0.6\text{m}; W = 8\text{m};$

$V = L \cdot H \cdot W = 300 \cdot 0.6 \cdot 8 = 1,440\text{m}^3 = 1,883.4\text{yd}^3$

$\text{Yd}^3 = 376\text{kg}; \text{average weight OTR tire} = 324.64\text{kg}; 24\text{inch} = 0.6\text{m}$

$1,883.4 \cdot 376 = 708,158.4\text{kg} = 708 \text{ tonnes}; 708,158.4\text{kg} / 324.64\text{kg} = 2,181 \text{ OTR tires}$

A total of 708 tonnes of tire shreds were used for this project, the equivalent of 2,181 OTR tires.



Image 5: Sections of OTR TD A Repair Southeast of Hamiota (Google, 2014)

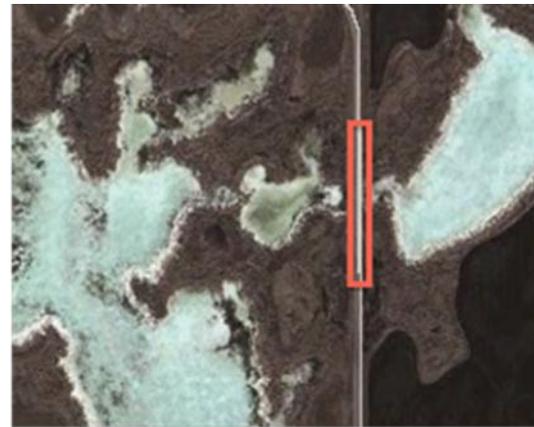


Image 6: Zooms of road sections Southeast of Hamiota (Google, 2014)

Figure 8. Road sections Southeast of Hamiota

### **Municipal Road 80N between 135 & 136W – 2013-2014**

The project site is located in the area of the RM of Hamiota, Manitoba, between 135 & 136W and the construction period took place in the summers of 2013 and 2014. The length of the road is 400 m and the width is 8m (Basic Design Standards in Manitoba - 1986). The underlying soil is silt, has poor load bearing properties and most often is affected by a ground high water table or has surface water on two sides of the road.

The road embankment was excavated and one meter and 0.60 meters of TDA layer was placed under compression with 6 passes of D 6 Cat or similar size track hoe. The TDA used for this project was Type B. 0.63 meters of compacted road building material was placed on top of the TDA, and the road was covered with a thick layer of gravel.

L= 400 m; H= 0.6m; W= 8m;

$$V= L*H*W=400*0.6*8=1920m^3 =2,511.3yd^3$$

$Yd^3 = 376kg$ ; average weight OTR tire = 324.64kg; 24inch=0.6m

$2,511.3 * 376 = 944,248.8kg = 944$  tonnes;  $944,248.8kg / 324.64kg = 2,908$  OTR tires

A total of 944 tonnes of tire shreds were used for this project, the equivalent of 2,908 OTR tires.

#### **4th Street between Spruce Avenue and Ash Avenue – 2014**

The project site is located in the former Town of Hamiota between Spruce Avenue and Ash Avenue and the road wasn't constructed by OTR. The construction occurred in 2014. The length of the road is 73.15m and the width is 8m (Basic Design Standards in Manitoba -1986). The road embankment was excavated one meter and 0.60 meters of TDA layer was placed without compression. The TDA used for this project was Type B. 0.63 meters of compacted road building material was placed on top of the TDA, and the road was covered with a layer of bitumen. This will be a very interesting project to supervise because the constructor did not use compression for the TDA layer, and that means the void between the tire shreds is larger than the projects mentioned above, and it is possible that in future years frost boils could appear in this road.

$L = 240$  feet = 73.15 m;  $H = 0.6m$ ;  $W = 8m$ ;

$V = L * H * W = 73.15 * 0.6 * 8 = 351.12m^3 = 459.25yd^3$

$Yd^3 = 376kg$ ; average weight OTR tire = 324.64kg; 24inch=0.6m

$459.25 * 376 = 172,678kg = 173$  tonnes;  $172,678kg / 324.64kg = 532$  OTR tires

A total of 173 tonnes of tire shreds were used for this project, the equivalent of 532 OTR tires.



Figure 9. 4<sup>th</sup> Street(Google Street View, 2015)

## Summary:

- TDA is beneficial to Manitoba because of its ability to handle our cold climate.
- TDA permeability makes it a feasible alternative to natural aggregate in high water table applications.
- Total PLT tires used for these projects is 465,520, the equivalent of 4,892 tonnes of TDA.
- Total OTR tires used for these projects is 9,074, the equivalent of 2,946 tonnes of TDA.
- For the Garven Road Project 9,600 sidewalls were used.
- The sections of road repaired with TDA were smooth and show no damage from frost lensing.
- This is the first conclusive evidence of the practical application of TDA 8 – 12” in Manitoba.

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