Tire Derived Aggregate
Embankment Design and Construction for Saskatchewan Highway 39

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Abstract

Saskatchewan recycles all tires, including passenger car and light truck tires, agricultural tires, and semi tires. It is environmentally and socially acceptable to recycle tires, and agencies in North America have been doing so for years. Recycling tires is important because scrap tires take up landfill space, pose a risk of fire when stockpiled incorrectly, hold water when not shredded, and can help conserve natural aggregate resources, depending on the application. Tire Derived Aggregate (TDA) is an engineered material made from shredded tires. TDA has been used in civil engineering applications as lightweight fill to build embankments, roadway ramps, weigh scales, backfill for retaining walls, and to repair frost heaves for over 40 years.

In 2022, the Saskatchewan Ministry of Highways (ministry) constructed the ministry's first highway embankment with TDA as lightweight fill. A greenfield project site on a new section of Highway 39 near Corinne required a large embankment fill for the southbound lanes and had in-situ soils that would benefit from the frost protection properties that TDA offers. TDA was utilized as lightweight fill in a location where the road embankment section was being built over an existing dugout. The TDA embankment section was 34.0 m by 147.6 m and 1.9 m thick and was constructed with a total of 6,332 cubic metres of TDA. Using a conversion of 100 tires per cubic metre of TDA, approximately 632,000 tires were recycled. A 2.95 m thick clay fill embankment with an additional soil surcharge layer of 0.75 m was placed on top of the TDA layer and allowed to settle prior to further construction. The surcharge load was removed to accommodate the pavement structure, and a flexible asphalt concrete pavement structure was constructed on top of the embankment, and the road was opened to traffic in 2024.

This paper presents the design and construction details for this project, the instrumentation used to monitor the TDA layer, and comments on lessons learned. The TDA embankment layer environmental and geotechnical monitoring is also summarized.

Introduction

Recycling tires is an important environmental and economic practice that addresses the significant waste generated by end-of-life tires. In Canada, tire recycling programs have been highly successful, diverting millions of tires from landfills and transforming them into valuable products such as rubber mulch, playground surfaces, and construction materials [1]. These initiatives not only reduce the environmental impact of tire waste but also contribute to the economy by creating jobs and supporting industries that utilize recycled rubber. Additionally, tire recycling helps decrease greenhouse gas emissions by reducing the need for new raw materials and minimizing the energy required for tire production [2].

The Tire Stewardship of Saskatchewan (TSS) oversees the province's tire recycling program, which ensures that scrap tires are collected and processed responsibly [3]. A review of TSS published annual reports indicates that close to one million tires are recycled through the program each year, amounting to approximately 25 million kg in weight [4]. By promoting sustainable waste management practices, Saskatchewan's tire recycling efforts contribute to a cleaner environment and a healthier community [5]. Furthermore, the economic advantages include cost savings for municipalities in waste management and the creation of green jobs within the province [6].

One of the engineered products of tire recycling is Tire Derived Aggregate (TDA). TDA is manufactured by shredding the old tires into smaller pieces, typically ranging from 25 mm to 300 mm long, and screening and separating the shreds into different sizes, for different uses. Metal pieces and debris, soil or organics are removed during production to ensure a good quality, consistent final product.

TDA is significantly lighter than traditional aggregates, with a density typically ranging from 500 to 800 kg/m^3, and when compacted, TDA layers have high porosity. In addition, TDA is highly elastic and is a good thermal insulator. NCHRP 435 outlines the most common uses of TDA [7].

Using TDA in road embankments offers several significant engineering benefits. One of the primary advantages is its lightweight nature, which reduces the load on underlying soils and minimizes settlement issues. This characteristic is especially beneficial in areas with weak or compressible soils, where traditional materials might lead to excessive settlement and instability. Additionally, TDA's excellent drainage properties help prevent water accumulation within embankments, thereby enhancing the overall stability and longevity of the road structure. The material's thermal insulation properties also play a crucial role in cold climates, as it reduces the risk of frost penetration and subsequent frost heaves, which can cause significant damage to road surfaces. Overall, incorporating TDA into road embankments is a practical and eco-friendly solution that addresses both engineering challenges and environmental concerns.

The TSS approached the Ministry of Highways in 2019 with the desire to provide TDA for a road construction project. A previous tire recycler no longer operating had accumulated a large pile of scrap tires in a stockpile located in the town of Assiniboia, SK and the tires had been sitting for many years, creating an environmental and fire hazard. The TSS was planning to have these tires processed to eliminate the old stockpile and was looking to repurpose them in a meaningful way on a larger scale.

To assist with the re-use of these tires in the form of TDA, the ministry focused on identifying a greenfield road construction project with significant needs for earth materials to construct the road embankment. After reviewing upcoming design and construction projects, a section of new highway being built as part of twinning, realignment, and passing lanes on Highway 39 near Corinne was selected for the TDA road embankment construction.

Objectives

The ministry was focused on the following objectives with respect to the TDA embankment construction:

- Provide a value-added solution for the large volume of TDA expected to be generated from shredding the legacy stockpile of scrap tires.
- Identify an optimal location for TDA use keeping in mind haul costs and minimizing the amount of earth excavation required.
- Install TDA in a highway embankment and monitor performance.
- Compare the performance of the TDA embankment to a conventional earth embankment.

During construction of the TDA embankment, instrumentation was installed to monitor the performance of the TDA. For comparison, instrumentation was also installed in a control section outside of the TDA embankment alignment. The information from this control section is not included in this paper.

Literature Review

TDA Applications

TDA is created from the shredding of scrap tires into sizes, with the shreds typically ranging from 50 mm to 300 mm in length. TDA is lightweight, free draining, produces low earth pressures, absorbs vibrations, is compressible, and has a thermal resistivity that is about seven times higher than conventional soil [8]. Because of these properties, TDA has been used as lightweight fill for embankment construction on weak, compressible foundation soils. Other applications for TDA include lightweight fill behind retaining walls and bridge abutments, thermal insulation to limit frost penetration below roads, drainage layers for roads, compressible inclusions behind integral abutments, vibration damping layers for rail lines, and landfill applications. TDA has also been mixed with soil to produce high strength composite materials.

TDA Design and Construction Considerations

When designing and constructing using TDA, the following parameters are important [8, 9, 10]:

- TDA Material Specifications:
    - TDA is made from shredding scrap tires into the sizes and gradations specified as Type A TDA or Type B TDA according to ASTM D 6270-20. They are produced by a shearing process. Type A TDA has a maximum dimension, measured in any direction, of 250 mm. Type B TDA has a maximum dimension, measured in any direction, of 450 mm. ASTM D6270-20 also provides details on the maximum exposed steel.
    - The material specifications for TDA takes into consideration the need to limit the potential internal heating of TDA fills, producing a material that can be placed and compacted with conventional construction equipment, and limiting exposed steel belts to allow for rubber-to-rubber contacts between the pieces when placed in a fill.
    - The TDA should be free of all contaminants including but not limited to oil, grease, gasoline, and diesel fuel that could leach into the groundwater or create a fire hazard. In no case should the TDA contain the remains of tires that have been subjected to a fire, because the heat of a fire may liberate liquid petroleum products from the tire that could create a fire hazard when the TDA is placed in a fill. The TDA should be free from organic matter such as fragments of wood, wood chips, topsoil, etc.
- Final In-Place Unit Weight of the TDA is an important parameter to be estimated during design. Evaluation of this parameter should consider compression of the TDA under its own self weight and the weight of the overlying soil.
- Calculation of Overbuild: TDA experiences immediate compression under an applied load. The top elevation of the TDA layer should be overbuilt to compensate for this compression to obtain the target compressed thickness of TDA.
- Time Dependent Settlement (Secondary Compression): For design, it is recommended to allow sufficient time for most of the time dependent settlement of the TDA to occur prior to paving.
- Cover Thickness above TDA: TDA should be covered with sufficient thickness of soil to limit deflections of overlying pavement caused by traffic loading. Soil cover as low as 0.8 m may be suitable for paved roads with light traffic. For paved roads with heavy traffic, 1 to 2 m or more of soil cover may be required. Regardless of the application, the TDA should be covered in such a way as to prevent contact between the public and the TDA, which may have exposed steel belts.

- Guidelines to Minimize Internal Heating Reaction: TDA fills should be designed to minimize the possibility of an internal heating reaction.
    - TDA materials need to meet the material specifications described in ASTM D6270-20.
    - TDA layers of greater than 3 m vertical thickness are not recommended. A 3-m TDA fill which is constructed based on current design ASTM guidelines should not experience an exothermic reaction resulting in self-heating that leads to combustion.
    - Fills should be constructed in such a way that there is no direct contact between TDA and organic matter. One possible way to accomplish this is to cover the top and sides of the fill with a 0.5-m thick layer of compacted soil. The soil should be separated from the TDA with a geotextile fabric.
    - Embankments constructed in accordance with the ASTM D6270 guidelines have shown no evidence of self-heating.
- Leachate: Based on previous research and as reported in the ASTM D627-20, TDA placed above or below the water table would be expected to have a negligible off-site effect on water quality.

TDA Layer and Embankment Design

The design of the TDA layer followed the general principles of ASTM D6270-20 “Standard Practice for Use of Scrap Tires in Civil Engineering Applications”. A typical section showing the TDA embankment preliminary design elements and overlying embankment design is provided in Figure 1. The original TDA design incorporated a 1.65 m thick layer of clay fill and a 0.75 m layer of pavement structure (for a total cover thickness of 2.3 m to 2.5 m) over a 2.7 m thick layer of TDA. For construction of the highway, the area of the TDA section required a relatively large grade raise of 2.3 m to 2.6 m above existing ground, which provided an adequate cover thickness over top of the TDA to accommodate the highway traffic loadings.

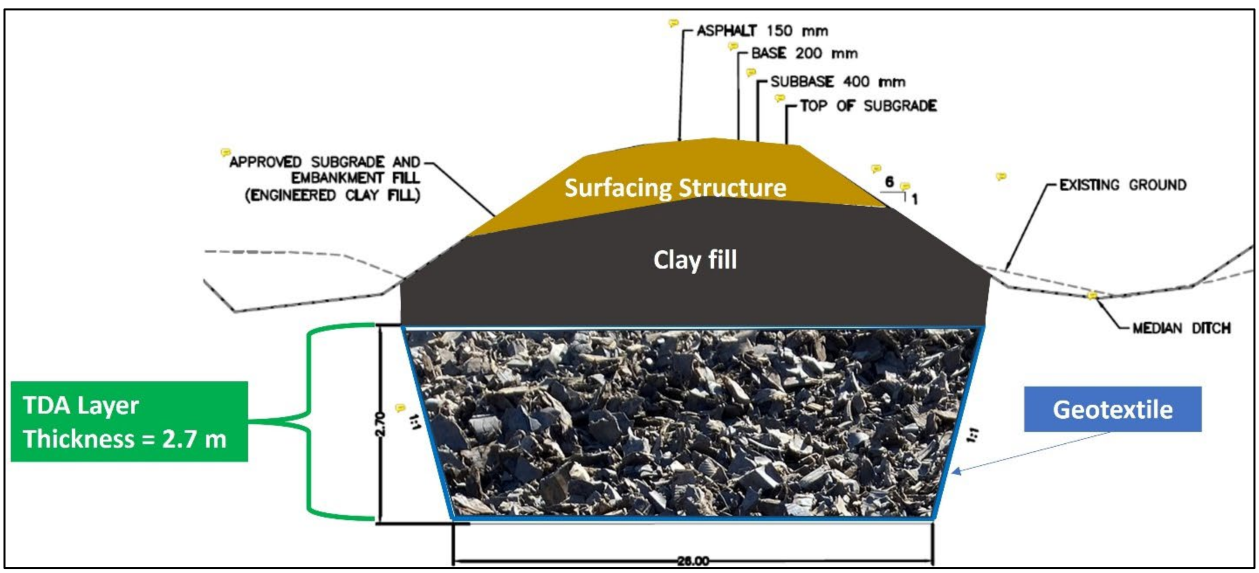


Figure 1. Preliminary Design Cross Section for Highway 39 Embankment and TDA Layer

During the design it was assumed that the TDA structure and overlying clay fill embankment up to top of subgrade would be constructed in the first season, followed by construction of granular subbase, granular base layers, and asphalt concrete, in the second season. Staged construction over two seasons allows for secondary compression of the TDA material to occur prior to placement of the pavement structure and is considered good construction practice.

The pavement design for the southbound lanes of the divided highway, including the section over the TDA, consisted of 400 mm of granular subbase, 200 mm of granular base course, and 150 mm of asphalt concrete. The lane width was 3.7 m, with an outside shoulder width of 3 m and inside shoulder width of 1 m. Lanes and inside shoulders were sloped at 2% with the outside shoulder sloped at 5%. Side slopes were designed at a ratio of 6 horizontal to 1 vertical.

The following are additional TDA design details:

- The design consisted of a 2.7 m thick TDA layer (after compression) with nominal dimensions of 31.4 m wide by 136 m long, and 5H:1V side slopes in the longitudinal direction, and side slopes of 1H:1V in cross section.
- The design accommodated an estimated available TDA volume of 8,600 m^3 (after compression).
- The design considered that the final thickness of TDA will reflect the actual available volume of TDA at the time of construction. In other words, if the available volume of TDA is less than the estimated volume, the clay fill cover thickness above the TDA would make up the difference. This flexibility in the future construction process was an important design element.
- The TDA design assumed a maximum compacted thickness of 2.85 m (before compression).
- Immediate compression of the TDA layer was estimated to be about 100 mm to 150 mm, so the final thickness of the TDA layer after compression was expected to be approximately 2.7 m.
- The design assumed that the TDA material gradation meets the ASTM D6270-20 requirements for TDA Type A as outlined in Section 7 Material Specifications of the standard including, but not limited to, gradation, metal fragments, protruding steel and free from organics, contaminants, and liquid petroleum products.
- The TDA design assumed that the embankment and subgrade above TDA will be constructed of approved fine-grained clay soils (engineered clay fill) compacted to a minimum 95 percent of the materials Standard Proctor maximum dry density (SPMDD) per ASTM D698.
- Some consolidation of the embankment fill was anticipated in the design. Consolidation of embankment fills up to 1.65 m in thickness was not expected to exceed 30 mm when placed and compacted to minimum 95 percent of the materials SPMDD.
- The TDA design considered a total cover thickness varying between 2.3 m and 2.5 m taken from the top of TDA (after compression) to the final top of asphalt surface. This cover thickness was selected given the relatively high traffic loading conditions and to limit deflections of the overlying pavement structure.
- The TDA design incorporated a completely wrapped TDA using a heavy weight geotextile to minimize infiltration of soil particles into the TDA voids.
- The TDA design included an impermeable engineered clay fill soil cover (using approved engineered clay fill) to prevent contact between the public and the TDA. The design included a minimum of 0.6 m soil cover on the 6H:1V embankment side slopes.

- The overall design of the embankment incorporated appropriate erosion control measures (i.e., topsoil and hydroseed or other appropriate measures) to protect the 6:H:1V side slopes from eroding.
- The TDA design also included a geotechnical instrumentation program whereby the performance of the embankment, pavement, and TDA layer can be monitored and compared to the performance of the embankment outside of the TDA footprint.

Construction Process

TDA Source and Quality Assessment

The Tire-Derived Aggregate (TDA) used in the Highway 6 embankment project was processed in Assiniboia, SK and stockpiled at a Ministry of Highways-owned gravel pit site near the town of Pangman, located approximately 50 km from the Highway 39 project site. The tire recycling contractor responsible for the production of TDA conducted regular material sampling and sent the samples to a ministry-approved laboratory for testing. When the contractor stockpiled the material for this project, it was found that the material that met ASTM D6270 had been mixed with previously shredded TDA material that did not meet ASTM D6270. The stockpile had localized areas of TDA larger than 450 mm, and there were localized areas of TDA with exposed wires longer than acceptable. To mitigate the impacts of mixed-in low quality TDA, the construction team was diligently inspecting TDA material hauled to site and had to dispose of some of the material that was grossly outside of the specification range. One load was rejected, there were no hydrocarbons in the TDA, and any soil or wood and large un-shredded tires were screened out or removed prior to placing the TDA in the embankment. Figure 2 shows an example of the TDA used in this project.

Figure 2. TDA Used in Highway 39 Embankment Construction

Following consultation with TDA design specialists, it was collectively decided that although the larger tire shred pieces and some TDA pieces with longer exposed wires may pose some additional challenges for compaction equipment, these impacts would be minimal enough to manage on site, and that construction should proceed. Because the TDA layer would be encased in approved clay fill soils, with no access to organic or hydrocarbon materials or water, the small amount of additional protruding wires was deemed to be acceptable.

Construction Methodology

Construction of the TDA embankment took place in the Fall of 2022. The existing dugout where the TDA was designed to be placed was widened during construction, as seen in Figure 3, to create a safe slope that would allow construction equipment to safely enter the existing dugout. The surface at the bottom of the dugout had localized areas of poor quality and wet soil, and a decision was made to excavate these soils prior to the TDA installation.

Figure 3. Highway 39 Dugout Preparation For Installation of TDA

The design dimensions of the TDA section were 31.4 m x 136.0 m, and the final as-built TDA dimensions were 34.0 m x 147.6 m. Figure 4 shows the woven geotextile installed along the base, sidewalls and top of the TDA to provide separation and containment for the TDA. TDA was delivered to site using side-dump trailers and distributed within the excavation using conventional earthmoving equipment as shown in Figure 4 and Figure 5, including dozers, skid steers, and excavators. The TDA material was placed and compacted in 300 mm thick lifts with a minimum of six passes per lift with a vibratory drum roller.

Figure 4. Highway 39 Embankment: Geotextile Fabric and TDA Placement

The contractor and construction staff commented that the installation went easier than expected, and they were able to complete the work efficiently, without any issues. Although longer protruding wires can pose a risk of flat tires on equipment, no issues were observed, and near the end of the TDA installation the delivery trucks were able to safely drive onto the installed TDA layer to dump their TDA loads. The construction of the TDA was recorded with a stationary camera set to collect hourly images, and a timelapse video of the installation is publicly available [11].

Figure 5. Highway 39 Embankment: Spreading and Compaction of TDA

Approved clay fill was placed and compacted in lifts on top of the finished TDA layer for a total cover thickness of 2.95 m, to match the design elevations for the earth embankment. In addition, a temporary surcharge earth fill of 0.75 m was installed, which was the equivalent thickness of the flexible pavement surfacing layers. This was done to accelerate compression of the TDA and to minimize its impact on the pavement structure. The finished earth embankment (top of surcharge) is shown in Figure 6. The clay fill material used to encapsulate the TDA was generally high plastic clay, with one sample classifying as low plastic clay. The California Bearing Ratio for the clay was 3, and the Plasticity Index ranged from 31.7 to 37.1. Clay is considered impermeable when properly compacted and is unable either to store water or let water pass through. Proctors and field densities were completed on the clay fill embankment materials to ensure they were suitable during the construction phase, as well as to ensure the embankment met contract specifications for earth embankment density.

Figure 6. Highway 39 Embankment (Top of Surcharge) After Construction in Fall of 2022

Figure 7 shows the final "as-built" compressed TDA layer that was measured to be 1.9 m thick, which is less than the 2.7 m thick assumed in the design. This is because there was less TDA volume available than initially estimated. The immediate compression of the TDA layer was designed to be 100 to 150 mm, and the measured results showed it to be 240 mm. This higher immediate compression is primarily due to the thicker soil cover that was placed on top of the TDA layer. The total soil cover thickness, including pavement, was designed to be 2.3 to 2.5 m, and the as built total soil cover thickness was measured to be 3.7 m. Additional soil cover was added to make up for the reduced TDA thickness to meet the design height of the final embankment. The secondary settlement of the embankment was measured to be 66 mm after 10 months. This amount of secondary settlement is reasonable based on the literature.

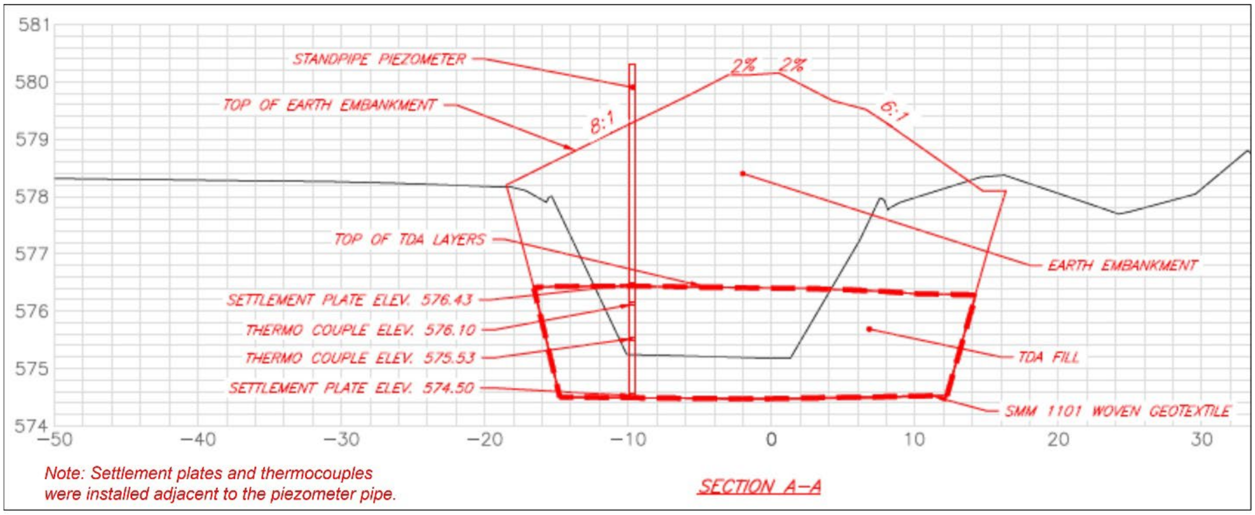


Figure 7. "As-built" Cross-Section of Highway 39 TDA Embankment

Table 1 compares the design versus the as-built and measured TDA parameters. In the end, there were 6,332 m^3 of TDA available, as expressed in compacted in-place volume. An amount of 8,600 m^3 of TDA was estimated at the time of preliminary design, based on input from the tire recycling contractor. Estimation of available volumes of loose TDA from the source stockpiles to a compacted and compressed unit weight in an embankment structure can be difficult to estimate because the TDA is not a uniform material. Based on the literature, the loose unit weights of TDA can vary from 3.3 kN/m^3 to 4.9 kN/m^3 in a stockpile, and compacted unit weights in an embankment can vary from 4.7 kN/m^3 to 7.5 kN/m^3.

Table 1. Comparison of Design and "As Built" TDA Layer Parameters

Parameter	Design	As Built (Measured)
TDA volume	8,600 m^3	6,332 m^3
Embankment size	31.4 m x 136.0 m	34.0 m x 147.6 m
TDA thickness after compression	2.7 m	1.9 m
Soil cover thickness	2.3 to 2.5 m	3.7 m
TDA layer immediate compression	Estimated at 100 to 150 mm	240 mm
TDA layer secondary compression	n/a	60 mm

TDA Embankment Instrumentation

The instrumentation installed in the TDA layer during construction is listed in Table 2 and shown in Figure 7. The installation included settlement plates, thermocouples, and piezometers. The settlement plates and thermocouples were installed adjacent to the piezometer pipe, within the TDA layer, as shown in photos in Figure 8. The vibrating wire piezometers were installed at the same location as the settlement plates. It should be noted that the instrumentation design, in addition to these instruments, called for the installation of two earth pressure cells. However, the instrumentation was sourced only two weeks prior to construction, and there was difficulty with acquiring some of the necessary equipment. The earth pressure cells were not installed and as a result, the density of the TDA fill was not able to be measured with instrumentation. During construction, a decision was made to install a monitoring well (standpipe piezometer) to enable the sampling of any water that may be collected at the bottom of the TDA.

Instrumentation and monitoring are important because the ministry has not used TDA in an embankment application before and wanted to understand how this material performs within the road embankment, as well as to manage any risks the TDA layer may pose. A data acquisition system was installed to obtain readings from the instrumentation. Measurements are taken automatically, in real time, and the readings are uploaded remotely. The intent of the instrumentation is to monitor the settlement, temperature, and presence of water in the TDA layer.

Table 2. Instrumentation installed in TDA layer

Instrument Type	Purpose	Installation Depth
Settlement Plates	Monitor vertical deformation of top of TDA layer and ground below TDA layer	Top of TDA (576.43 m) Base of Excavation (574.500 m)
Thermocouples	Track internal temperature of TDA	VW01 TIP (574.187 m) TC02 TIP (576.096 m)
Vibrating Wire Piezometers	Detect pore water pressures	Bottom of TDA layer (574.500 m) Top of TDA layer (576.430 m)
Monitoring Well (Standpipe)	Ability to collect water samples	Bottom of TDA layer (574.500 m)

a) Thermocouple installed in TDA layer

b) Settlement plates on TDA and monitoring well

Figure 8. Highway 39 TDA Layer Instrumentation and Monitoring Well

Construction of the Surfacing Structure

The TDA layer, the clay fill embankment, and the temporary surcharge earth fill were constructed in the Fall of 2022 and allowed to settle until 2024. In 2023 and 2024, instrumentation was installed in the subgrade and pavement structure above the TDA embankment, as well as in a control section with no TDA, outside of the TDA embankment for comparison purposes. This information is not included in this paper. In 2024, the 0.75 m temporary surcharge fill was removed, and the pavement structure consisting of 400 mm of granular subbase, 200 mm of granular base course, and 150 mm of asphalt concrete, was constructed as designed.

TDA Embankment Instrumentation Results to Date

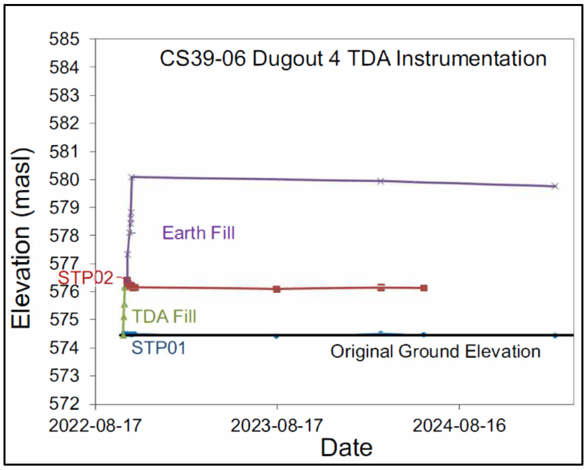
Figure 9 provides monitoring results to date for the TDA layer. The monitoring Well (MW01) within the TDA fill has been dry since initial TDA embankment construction.

As previously mentioned and illustrated in Figure 9 a), the TDA layer settled 240 mm immediately under the 3.7 m earth embankment with surcharge. During design, an immediate compression of 100 to 150 mm was predicted for approximately 2.3 to 2.5 m of fill above the TDA. While the actual compression is considerably more than predicted in design, the increase is reasonable, given the significantly greater earth fill installed above the TDA. After the initial compression, it was observed that the TDA fill settled an additional 66 mm after 10 months. Settlement pin plots will be generated once they are installed by the Ministry in 2025. The vibrating wire piezometer data in Figure 9 b) indicates that the subgrade did not show significant porewater pressure response.

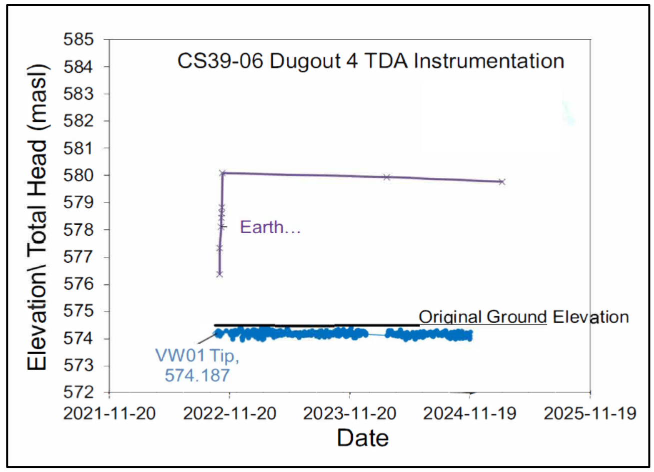
Figures 9 c) and d) presents the temperature data. After the initial variation during TDA layer construction, both TDA layer temperature sensors VW01 TIP and TC02 TIP stabilized at 8.5°C and 7.5°C, respectively. The most recent temperature measurements, taken in November 2024, were 9.0°C for VW01 TIP and 35.0°C (blue arrow on the plot) for T02 TIP. The high reading of 35.0°C for T02 TIP could be a false reading or could be an error in the data processing, because the sensor corrected itself at the next hour to 14.0°C, and then reduced further to 9.0°C. The highest temperature observed in TCO2 TIP was 14.0°C. Periodic observation of temperature readings will continue for the near future, to determine why the temperature peaked two years after construction.

Outside the unusual readings, the measured TDA temperature trends follow an expected seasonal trend and are like those recorded in New Brunswick's highways TDA embankment [10]. As the heat leaves the TDA layer in the fall, the temperature decreases.

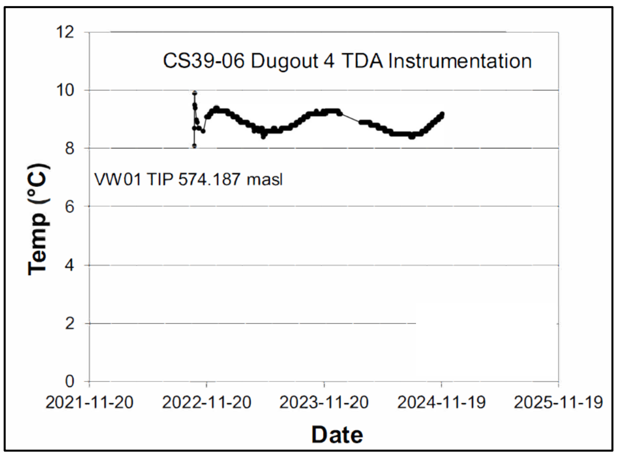
The ministry has temperature sensors installed on several highways to measure pavement temperature and frost depth. The sensors nearest to the TDA embankment are located at Francis, Saskatchewan. The temperature at 2.4 m below grade, which is the depth of TDA embankment VW01 TIP, was -4.5°C and 14.0°C in November 2024 and June 2024. The temperature at 2.97 m below grade, which is the depth of the TDA embankment TCO2 TIP, was -1.0°C and 14.0° in November 2024 and June 2024, respectively. The temperature measured in the TDA layer stabilized at 8.5°C and 7.5°C, for the 2.4 m and 2.97 m depths, respectively. The higher temperatures measured in the TDA embankment are reflective of the insulating material properties of TDA.



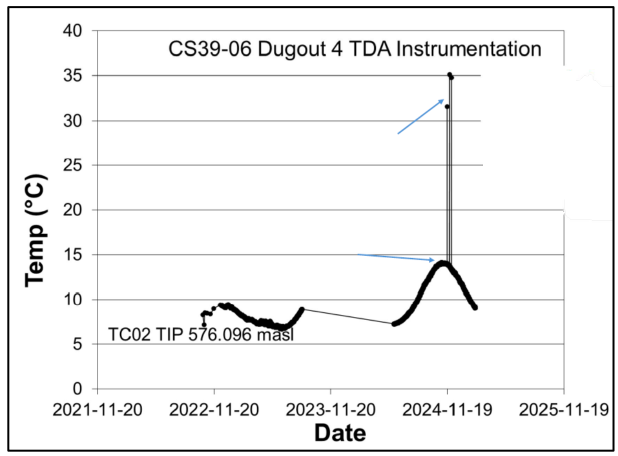
a) TDA layer elevation data



b) TDA layer elevation/total head data



c) TDA temperature at 574.187 m elev.



d) TDA temperature at 576.096 m elev.

Figure 9. TDA Layer Instrumentation Data (Source: SoilRocks Inc. Instrumentation Report 2025)

Observations and Lessons Learned

As with any new technology or material trials, there are bound to be valuable takeaways that can serve to improve the outcomes for future projects. The following are observations and lessons learned from the Highway 39 TDA embankment project:

- While the volume of TDA is a fundamental assumption in design, it is difficult to estimate with accuracy. Over- or underestimating the TDA volume impacts the final thickness of the TDA layer, soil cover thickness, and surcharge, and settlement. Changes to earth quantities are likely to occur due to the lack of exact information. Design of TDA projects should take into account the possibility of over or underestimating the available volumes of TDA for a given project.
- Enlisting engineering support during design and construction of TDA projects from experienced engineers who understand how to work with TDA is valuable to ensure project success.
- The instrumentation plan for a TDA embankment should be determined during the design phase, and the instrumentation should be purchased well in advance of the construction phase. Hand-over notes from the design to the construction team should include the instrumentation

plan and list of all necessary equipment. This will enable sourcing the correct equipment in time for installation, which in turn will prevent delays or data gaps.

- A datalogger that provides daily readings is helpful for real-time TDA layer monitoring.
- Using TDA in embankment construction is not complicated, and installation can be completed using traditional construction equipment and efforts.
- Design engineers and TDA experts should be consulted as soon as any changes to the TDA embankment design or instrumentation plan are contemplated during the construction phase. The decision to add the monitoring well was made at the time of construction to allow water quality sampling and testing if needed.
- Staging the TDA embankment construction to occur a year or two prior to the pavement structure construction allowed the time dependent settlement (secondary compression) of the TDA to occur and provided time to monitor its performance.
- Applying a temporary surcharge load in the form of additional earth fill can be used to successfully mitigate the impact of TDA compressibility and settlement.
- One of the local landowners was highly concerned about the environmental implications of the ministry using TDA in the dugout. Working closely with stakeholders and public relations as early in the project life as possible is important when trialling a product that is new to the jurisdiction, even when it is well-used in other jurisdictions.

Concluding Remarks

Overall, the installation of TDA in the Highway 39 earth embankment can be considered a success. The Government of Saskatchewan successfully recycled approximately 632,000 cubic metres of used tires in this first of its kind Saskatchewan highway construction project. The new lanes on Highway 39 are in operation, and the TDA layer continues to perform as intended three years after installation. The ministry plans to continue monitoring the instrumentation for the near future, and in addition to the TDA, other instrumentation was installed to monitor the pavement above the TDA. Future work may include comparison of performance between the TDA embankment and the adjacent earth embankment, an update on the temperature trends within the TDA layer, and an assessment of pavement performance at this location.

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