Blacksnake Creek Stormwater Separation Tunnel - An American First.

The First 100% Synthetic Fibre Reinforced Precast Tunnel Segments in North America

Owner: City of St. Joseph, Missouri.

Designer: Black and Veatch Corporation.

Contractor: Super Excavators, Inc.

Segment Manufacturer: CSI Tunnel Systems.

Reinforcement: BarChip Inc.

www.barchip.com

BarChip Inc.
The Synthetic Fibre Experts

Introduction

To meet regulatory requirements of the Environmental Protection Agency and the Missouri Department of Natural Resources, the city of St. Joseph, MI, will separate and redirect a portion of the stormwater runoff from the Blacksnake Creek watershed to a dedicated outfall near the Missouri River. A key element of the plan is the Blacksnake Creek Stormwater Separation Tunnel.

Currently under construction, the new Blacksnake tunnel system will reduce the volume of untreated wastewater released by up to 60%, with future works reducing release by up to 85%. Additionally, it will eliminate the cost of treating up to 2 million gallons per day of creek water at the water processing plant.

Image 1: *Tunnel alignment from Second Harvest along Highland Ave.*

Blacksnake Tunnel

- 2.0 km (1.3 miles) in length with an Internal diameter of 2.75 m (9 feet).
- Excavated by EPB TBM
- 16 m (53 foot) dual baffle drop shaft with 11 m (37 foot) internal diameter.
- Constructed in soft and mixed ground including soils and shale.
- Ground support consists of 100% Barchip synthetic fibre reinforced precast segmental lining.

The tunnel alignment runs west from the Drop Shaft and proceeds underneath populated areas, crossing below Interstate 229 and in-service railroad tracks before terminating at a new Energy Dissipation Structure.

The tunnel geology is soft ground and mixed ground conditions, including soils and shale, and combinations of both at interfaces. Considering the ground conditions along the tunnel alignment and the proximity of the drop shaft to commercial and residential areas, excavation with an EPB tunnel boring machine was required.

To launch the TBM a 16 m diameter secant pile shaft with a cradle placed inside was constructed. A special electrical and hydraulic umbilical assembly was designed to help launch the TBM. During this stage, a precast concrete segmental tunnel liner “half-ring” structure was used to push and advance the TBM further into the excavation.

Image 2: *Blacksnake EPB Tunnel Boring Machine*

Image 2: *Blacksnake TBM launch with BarChip fibre reinforced “half-ring”.*

BarChip Reinforced Segmental Lining

The segmental lining is made of precast concrete segments installed by the TBM during advancement. Each ring is composed of 6 trapezoidal segments with rubber gaskets for water tightness *(Image 3)*.

Segment dimensions are 190.5 mm (7.5 inches) thick and 1219.2 mm (48 inches) wide, with an internal diameter of 2.7 m (9 feet) and an aspect ratio of 8.1. The segments were manufactured by CSI Tunnel Systems, Inc. in Macedonia, Ohio, with a concrete class of C40/50 at 28 days and a stripping strength of 14 MPa.

The segments are placed using a segment erector located in the trailing shield and are manually bolted together *(Image 6)*. Backfill and contact grouting of the annular space is performed through cast in grout ports in each segment after installation.

BarChip macro synthetic fibre was chosen as the sole reinforcement for the segments primarily to comply with America Iron and Steel provisions. While this application is a first of its type in North America, BarChip had been used previously in major USA tunnelling projects such as the Caldecott 4th Bore, Devils Slide and Euclid Creek CSO starter and exit tunnels.

Based on previous experience with BarChip fibre reinforcement in the Euclid Creek CSO tunnel, Segment manufacturer CSI Tunnel Systems, Inc. were comfortable in recommending BarChip for the Blacksnake tunnel segments.

There were no objections to the use of BarChip fibre reinforcement provided the segments met the performance specifications, specifically, a minimum compressive strength of 41.4 MPa (6,000 psi), minimum flexural tensile strength at 28 days of 4.62 MPa (670 psi), and minimum residual flexural tensile strength of 3.17 MPa (460 psi).

Image 3: *Post-production stacking of BarChip fibre segments.*

Image 4: *On-site storage of BaChip fibre segments after transport.*

Image 5: *On-site storage of BaChip fibre segments after transport.*

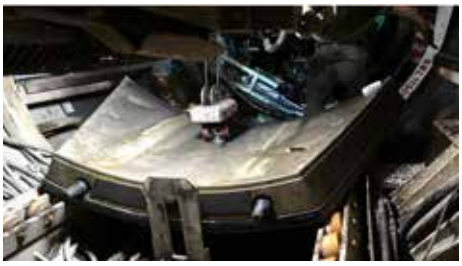

Image 6: *In-situ placement of BarChip fibre reinforced segment.*

Image 7: *Installed BarChip reinforced rings in the Blacksnake Tunnel.*

As of March 2019, the tunnel drive on the Blacksnake Creek Stormwater Separation Project is 30% complete. The TBM is advancing trouble free and has installed roughly 500 fibre reinforced segmental tunnel lining rings, roughly 610 meters. The tunnel is advancing at a single shift daily rate, between 12 to 14 meters.

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BarChip Macro Synthetic Fibre Reinforced Segments

On The Blacksnake Tunnel Project

Benefits

BarChip macro synthetic fibre reinforced segments deliver deliver many benefits over traditional cage reinforcement .

BarChip fibre reinforcement reduces overall cost. On the Santona Laredo tunnel, BarChip reduced the cost of segment production by almost 40%.

BarChip fibre reinforcement eliminated the risk of corrosion, which is critical for CSO tunnels such as Blacksnake.

BarChip fibre reinforcement eliminated the need to manufacture and install traditional steel cage, simplifying the production process.

Blacksnake tunnel highlights the effectiveness of BarChip fibre reinforcement in utility tunnels such as water, power, irrigation and gas transfer.

Performance

The overall performance of the BarChip fibre reinforced segments has surpassed the contractor's expectations. The indicating factors of the performance of the machine, durability and robustness of the segments, and performance of the crew all facilitate meeting the project goals. The BarChip fibre reinforced segments easily met the project specifications of;

Minimum compressive strength of 41.4 MPa (6,000 psi),

Minimum flexural tensile strength at 28 days of 4.62 MPa (670 psi), and

Minimum residual flexural tensile strength of 3.17 MPa (460 psi).

Reliability

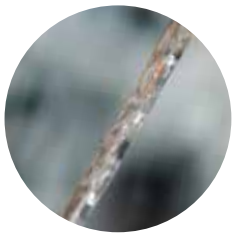
The initial tunnel drive installation has proven that BarChip fibre reinforced segments are robust enough to withstand the temporary load cases. With the tunnel 30% complete (March 2019), BarChip fibre reinforced segments have proven successful in;

Post-production demoulding, hoisting and stacking,

Transportation and transfer to on-site storage, and

Handling and installation with a single point mechanical erector.

Furthermore, the half-ring segment sections used in the shaft for the launching process were inspected after the initial push with no damage recorded.



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