Lower Fox River Operable Unit 1 2005 Remedial Action - Summary of Geotextile Tube Failures

PREPARED FOR: GW Partners
PREPARED BY: Benny Vine
Mike Jury/CH2M HILL
COPIES: Dan Plomb/CH2M HILL
Jeff Lamont/CH2M HILL
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This memorandum summarizes the description, analysis, and recommendations associated with the geotextile tube failures at the Lower Fox River Operable Unit 1 2005 Remedial Action.

Background

Sediment dewatering activities at the site were implemented utilizing geotextile tubes constructed of Geolon GT500 or a high strength polyester fabric. These geotubes were manufactured by Miratech™ and Bradley Industrial Textiles, Inc. (Bradley), respectively. During 2005 RA operations, five of the sixty-three geotubes utilized for dewatering operations experienced some type of failure. Below is a discussion of each failure and corrective actions that were implemented.

Geotube Failure No. 1

On September 20, 2005, an 80-ft. circumference x 203-ft. long geotube manufactured by Miratech™ failed in the northeast section of the dewatering pad. This tube was labeled no. 12 per the Dewatering Pad Management Plan. The geotube was filled with Sub-Area A sediment from the top utilizing three fill ports. This geotextile tube had not received material since September 8, 2005. Prior to the failure, numerous holes, approximately 4-inches in diameter, were installed in the top and north side of the geotube in order to install wick drains to enhance dewatering and to sample sediment. This geotextile tube was the end unit on the first row of stacked geotextile tubes and had experienced a "bulge" on the eastern half of the tube one week before the failure occurred. A smaller circumference and shorter geotextile tube was installed immediately adjacent to the "bulge" in the tube in order to provide lateral support. However, the entire length of the geotextile tube was not laterally supported and the failure occurred at the unsupported area. Approximately 50 cy of thickened sediment slurry material (estimated to be on the order of 20% solids) was released near the failure site. The viscous nature of the material helped reduce the amount of material that was released and it was fully contained within the dewatering pad.

Analysis and Recommendations

Once stabilization of the spilled sediment material was complete (utilizing hay bales), CH2M HILL photo-documented (photos are appended to this report) the breached section

of the geotextile tube and began corresponding with Miratech™ personnel to determine the cause of the failure. The second-tier geotextile tube stacked on top of the geotube was also retired to prevent further breaching of the tube. A sample of the geotextile tube fabric from the breached area was also collected by CH2M HILL and submitted to Miratech™ for analysis.

A comprehensive report was submitted to CH2M HILL by Miratech™ on October 31, 2005 and is attached as Attachment 1.

The report concluded that the geotextile tube was being filled properly and to the proper height. Analysis of the fabric concluded that tearing and separation of the fabric was not due to fabrication or fabric conditions. It is believed that the additional holes installed in the top and side of the tube, especially when the material in the tube was too fluid (low percent solids), caused the failure of this geotextile tube.

In the future, additional holes will not be installed in geotextile tubes and geotextile tubes will not be stacked on before the sediment has sufficiently dewatered to act as a solid material and not a fluid.

Geotextile Tube Failure No. 2

On October 24, 2005, an 80-ft. circumference x 200-ft. long geotextile tube manufactured by Bradley Industrial Textiles, Inc. failed in the southwest section of the dewatering pad. This tube was labeled no. Brad-1 per the Dewatering Pad Management Plan. The tube was filled with Sub-area POG 1 sediment from the top utilizing three fill ports and was being filled when the failure occurred. Each fill port resembles a "sock" due to the type of fabric the tube is made of. The design height of the tube was approximately 18-ft. and the tube was approximately 14-ft. high when the failure occurred. Several days prior to the tube failure, large concrete blocks had been placed on each end of the tube to assist in dewatering of the tube. At the time of the failure, the western end fill port was the primary port being used to fill the tube. A PVC "stinger" pipe was inserted into the fill port to aid in filling activities which is standard procedure. Dilute sediment slurry material was released inside (estimated 150,000 gallons) and outside (estimated 100 gallons) the dewatering pad as a result of this failure.

Analysis and Recommendations

Once stabilization of the spilled sediment was complete, CH2M HILL photo-documented (photos are appended to this report) the breached section of the geotextile tube and began corresponding with Bradley personnel to determine the cause of the failure. A report was submitted to CH2M HILL by Bradley on December 9, 2005 and can be found in Attachment 2.

The Bradley analysis concluded that the geotextile tube had not reached its maximum height capacity (approximately 75% full) and, therefore, fabric strength was not the cause of the tube failure. The Bradley analysis concluded that placement of the concrete block on the western end of the tube where the breach occurred caused restricted flow down the center of the tube creating a mound of material in front of the flow path in the tube. This restricted flow could have caused the PVC "stinger" to press into the fabric next to the fill port causing the fabric to tear in this area.

CH2M HILL's analysis of the failure concluded that the "mound" of material restricting the flow path in the tube was not created by the concrete block, but from rock and other dense solids being pumped into the tube at this location. This was accentuated by the fact that the fill ports were installed too close to the end of the tube (7.5 feet instead of 17.5 feet). The mound of material was also left to dewater over a weekend in which the "mound" became consolidated and the tube was not able to pick itself back up once dredging activities began after the weekend.

In the future 100-ft. circumference tubes will not be filled above 10-feet in height. Also, concrete blocks will not be placed on Bradley tubes and PVC "stinger" pipes will be removed once the tube reaches a pre-determined height.

Geotextile Tube Failure No. 3

On or about November 15, 2005, an 80-ft. circumference x 174-ft. long geotextile tube manufactured by Miratech™ began to tear in the center and west end of the tube. There was no release of sediments. This tube was labeled no. B-11per the Dewatering Pad Management Plan and was located on the second-tier of geotextile tubes in the southeast section of the dewatering pad. Subsequently, the southwest corner of the tube was punctured by the off-road forklift during catwalk placement/removal activities. This puncture caused approximately 2 cy of sediment to be released to the dewatering pad.

Analysis and Recommendations

Site personnel were made aware of the tear and puncture and instructed to monitor the status of the tube. The end of the tear was stabilized with an industrial epoxy glue to prevent further failure, and filling of geotextile tubes stacked on top of it was halted.

Geotextile Tube Failure No. 4

On November 22, 2005, an 80-ft. circumference x 200-ft. long geotextile tube manufactured by Bradley Industrial Textiles, Inc. failed in the northeast section of the dewatering pad. The tube was being filled with Sub-area C/D2S material at the time of the failure and appeared to tear on the underside of the tube. An estimated 150,000 gallons of dilute sediment slurry was released onto the northeast quadrant of the pad as a result of this failure. The tube was labeled no. NEB-1 per the Dewatering Pad Management Plan.

Analysis and Recommendations

Once stabilization of the spilled sediment was complete, CH2M HILL photo-documented (photos are appended to this report) the breached section of the geotextile tube and began corresponding with Bradley Industrial Textiles, Inc. personnel to determine the cause of the failure. A report was submitted to CH2M HILL by Bradley on December 9, 2005 and can be found in Attachment 2.

The Bradley report concluded that the geotextile fabric had been snagged or torn, either during production, packaging, transport, or during initial tube installation/rollout activities, which caused the tube to fail once sediment slurry began filling the tube.

Based on this failure, inspection procedures were added to the deployment activities, such that if a tear occurred in any part of the process prior to filling, it would be observed.

Geotextile Tube Failure No. 5

On December 1, 2005, an 80-ft. circumference x 116-ft. long geotextile tube manufactured by Miratech™ failed in the northwest section of the dewatering pad. This tube was labeled no. B-M6 per the Dewatering Pad Management Plan and located on the second-tier of geotubes. The tube was being filled with Sub-area C/D2S material at the time of the failure and appeared to tear on the underside of the tube. An estimated 150,000 gallons of dilute sediment slurry was released onto the open area around the northwest quadrant of the pad as a result of this failure. A 3-inch trash pump was used to pump some the spilled material into a separate geotube in order to decrease the amount of spilled material on the pad.

Analysis and Recommendations

CH2M HILL photo-documented (photos are appended to this report) the area of the geotextile tube where material was released from the tube and began corresponding with Miratech™ personnel to determine the cause of the failure. On December 2, 2005, a Miratech™ representative was on-site to photo-document the tube that failed. Due to the location of the breached area underneath the tube and the inability to inspect that area, the specific cause of the failure is not known at this time. It is anticipated that the breached area of the tube can be viewed and fabric samples collected when loadout activities occur in this section of the pad in 2006.

Attachment 1

Miratech Reports

Glenn M. Lundin
Miratech
3971 Iroquois Ct.
Rhinelander, WI 54501

Oct 31, 2005

Ben Vine
CH2M Hill

Subject: Separation of Geotube® container.

Dear Ben.

I would like to summarize the cause of the separation of Geotube® # 12. I will also summarize the information send to you in my email dated 10-14-05. The test results on the fabric will also be discussed.

The resultant tearing and separation of fabric was not due to fabrication or fabric conditions.

Fabric test results showed that the fabric tested out at 630 lbs/in for machine direction. Specification for fabric for machine direction is 4,800 lbs/ft divided by 12 is 400 lbs/in. The cross machine test showed 886 lbs/in while specification shows 6600 lbs/ft divided by 12 is 550 lbs/in. You can see that fabric strength is not a factor.

Email summary:

- #12 Geotube® container was filled to proper height with normal dewatering.
- It was the end unit on the first layer.
- It is an 80 ft circumferential by 203 ft long, with 3 Geoport® fill ports.
- After initial dewatering the 3 Geoport® fill ports were cut out for potential other uses.
- Five additional similar size holes (about 12+") were cut out along the top of the unit to evaluate other drying methods.
- 8 to 15 small about 4" square or triangular holes were cut along the top to take core samples for consistence.
- Small Holes (about 4" square.) were also cut along the sides about every 3' to 6' and a drainage wick was driven into the solids
- At time of placing the second layer on the solids in the first layer ranged 35% to 45% in the lower solids area of the Geotube container. 50% and above in other areas of the same unit.
- The second layer Geotube container was placed properly and was being filled properly.
- Once the breach occurred, filling into the top unit that was supported by the breached unit was stopped immediately.
- Breached solids were covered to ensure solids would not be washed away by the weather.
- Hay bails were added to the beached solids area to soak up and contain any solids that would get wet due to drainage from second layer and weather conditions.

- Bulging out at certain locations on the side that did not have anything in there was noticed.
- Breach appeared to occur from center top (under second layer) down.
- Breach started in the third panel from the end and then into the forth panel (I could not remember if it also went into the next panel.)
- Material inside was of sufficient solids so it just sluffed to the side and did not run out or go over the birm.
- The second layer provided normal loading on the first layer.

As mentioned during my visit, and based on these facts and comments, along with the pictures and discussing the breach with several Miratech engineering and manufacturing personnel, it is believed that the cause of the breach was due to the fact that the fabric had numerous holes cut out along the top resulting in additional stresses on the fabric material that was left. In addition, sections of the Geotube container solids level was low enough to move under pressure (second layer), a normal condition. Then there was no support in the form of another unit next to it to stop lateral movement, a normal condition. These normal factors, tied with the weakening of the fabric with all the holes, caused the failure of the fabric. We will of course check on the fabric test results and relay them in a letter once we have them.

This information shows that our original discussion was correct and your immediate action and changes in not making additional holes was the correct steps for safe and maximum optimization of Geotube® containers.

Please let us know if we can be of further assistance or if any additional information is necessary.

Sincerely,

Glenn M. Lundin

Glenn M. Lundin

Cc: Tom Stephens, Mark Gunzenhauser, Miratech

Geotubes® Geobags® Geocontainers®
3971 Iroquois Ct. / Rhinelander WI 54501 / 715 369-2598 / Fax 715 369-5263 / glenn_lundin@rtcusa.net
3680 Mount Olive Road / Commerce, Georgia 30529 / 706 335 3400 / 1 888 795 0808 / Fax 706 335 3405
A division of Ten Cate Nicolon USA

Glenn M. Lundin
Miratech
3971 Iroquois Ct.
Rhinelander, WI 54501

December 27, 2005

Ben Vine
CH2M Hill

Subject: Bottom breach of second layer Geotube® container.

Dear Ben,

After visit to the site on December 2, 2005, reviewing the pictures, and discussions with our technical people I would like to provide our initial report. We request that when you get to the date that you will be removing the solids from that Geotube® container that you notify me. I would like to be present to get a close look if possible and to take a section of fabric to have analyzed.

The question of cold weather affect on the fabric was raised. We can report to you that the cold / freezing of the fabric does not cause any degradation. Ten Cate Nicolon, during the development of the Geotube® fabrics, had an independent lab run samples on polypropylene material that is the same base material used in the Geotube® container dewatering fabric. I have attached a copy for you files.

This brings us to the question of what could have caused the breach. I will provide several options in the order that we think is the most likely. Each section will have facts and a summary providing reason for the option. Hopefully when the removal of that section is being done, we will get more definitive answers through inspections and testing.

Option A: Stacking on Bradley units with deep notch.

- The breached Geotube® container was on the second layer.
- First layer contained a 100 ft circumferential Bradley spiral tube.
- The weakest seam of any geocontainer is the longitudinal seam. Geotube® containers, with a circumference greater than 30 ft, all have this seam on the bottom. This seam is designed for full support, even when stacking. This is the area that appears to have failed.
- The Bradley design generates a much steeper slope on the sides of the tube which creates a very deep vee notch.
- The solids concentration in the Bradley tube appeared to a lot less than desired for support of a second layer. No one had this number during my visit, if available that would help.
- The Bradley tubes, besides having steep sides, also tend to not lie straight causing a gap between it and the next unit. This can be seen in picture A.

- The vee notch between the two bottom units had a single bale of straw, which was really to aid in the laying out of the stacked unit. In this case a single bale was insufficient and did not really support the unit during fills. Picture A.
- Freezing does not affect fabric strength. If top and side are frozen, this would cause the bottom to be the location where filtrate must escape.
- The Bradley design result in a deep Vee notch caused by the steep slope, not laying straight, gap, and low solids which added together causes the notch to widen and open even more. Resulting in an unsupported bottom seam causing additional stress. This would also cause the true fill height, (the lowest point in the notch to the top of the unit), to easily exceed the designed requirements.
- Miratech™ Geotube® containers should **not** be stacked on top of Bradley units because of the Bradley design, or other manufacture's units. Miratech™ Geotube® containers should only be stacked on top of other Miratech units. The Geotube® container is designed for tight connections with flatter sides and aids in positioning which provides proper spacing, small notches, optimum dewatering, and stability. Example of Miratech™ Geotube® proper placement is seen in picture B, which was taken at the same time. Note the tight fit between units as a result of the design, small notch, and flatter sides, all these advantages of the Geotube® container provides for optimum filling and safe stacking.
- **Summary**: The design of the Bradley unit is the basic cause of the failure due to the deep notch, steep sides, possible lower solids, and gap which caused the Geotube® unit to be filled beyond its design height. With no support on the bottom seam it separated along the bottom.

Picture A: Geotube® unit sits on Bradley. East View, notice gap & deep notch.

Picture B: Geotube® units stacked with nice tight notch.

Option B: Damage to unit.

- While placing Geotube® unit it is possible that it slid across a sharp object such as piece of rebar or other sharp debris found in the dewatering cell.
- Unit was damaged by forks during transit, on site moving, and / or placement.
- Unit was dragged across a sharp object causing a cut of several layers of fabric.

- A sharp object was possibly dredged into the unit, settled on the bottom of it and with the increased solids and weight caused a cut or weakening of fabric.
- **Summary:** It is very unlikely that this option occurred because of proper handling and inspections by crews prior to and during installation. This option can also be easily verified during the removal of the unit by inspecting for any foreign object and evaluation of the fabric.

Option C: Faulty fabric or seam.

- Faulty seam or fabric on the bottom of the unit.
- **Summary:** Very unlikely since the bottom of each Geotube® unit is inspected during the sewing process, then when it is put on the core for shipping the bottom and especially the seam is inspected. Also during placement at the site the crew is looking at the bottom as they unroll the unit for placement. Since the crew has done numerous units it is unlikely that they would miss any obvious flaws.

I hope this summary and evaluation provides the information and explains what happen to the breached unit. If you would please provide me an approximate date when the unit will be opened and removed and a contact I can call to confirm the date and time I would greatly appreciate it. At that time I would be able to better inspect the bottom of the unit and the other conditions and objects in the area. I would also be able to take a section of fabric and send it down for analysis.

Please let us know what else we can do to assist with. We look forward to providing our service, technical knowledge, with a quality product for this and all your projects.

Best Regards,

Glenn M. Lundin
Miratech Market Manager

Cc: T. Stephens, B. Wilbanks, M. Gunzenhauser: Miratech
D. Plomb: CH2M Hill

Attachment 2

Bradley Industrial Textiles, Inc. Report

From: Geotextile@aol.com [mailto:Geotextile@aol.com]
Sent: Friday, December 09, 2005 4:49 PM
To: Plomb, Dan/MKE
Cc: Vine, Benny/MKE
Subject: Report on my opinion of two Spiral*geotube Breaches

Several visits to the jobsite as well as a complete review of the pictures has formed my opinion as to the cause of the breaches in two of the Spiral® containers.

(Schedule B) picture shows the first occurrence and breach. This tube was designed using a high strength woven polyester fabric with a wide width tensile strength of 20,400 lbs/ft in the machine direction and a 16,800 lbs/ft in the cross machine direction.

The strength required to fill this 80' circumference tube to the 15' height it had been brought to several days earlier was only 6,020 lbs/ft by 4,272 lbs/ft (See Schedule A). This rules out the fabric strength as the cause.

There were two additional factors that could have contributed to the cause.

Placement of a large concrete block to load and press the water is a risky method, especially when left on top of the tube for several days as this was.

The area directly under the block was a lower elevation and required extra lift because of the weight of the block in relation to the upper portion of the remaining surface.

This could cause abrasion to the bag and result in a rupture.

The second contributing factor was the large accumulation of solids that formed a camel hump in front of the flow or channel required to evenly distribute the new slurry throughout the container.

This restriction allowed the front of the tube to build additional pressure by the restriction of the hump and block.

This eventually pushed the solids that had been dewatered toward the back inlet.

The back inlet was still occupied by the rigid PVC pipe which was in turn forced into the inlet trunk. As the top of the pipe was forced over taking one half of the sleeve with it leaving the forward half still attached to the circle or hole where the sleeve had originally been attached (See Schedule B).

Recommendations:

1. **Remove all rigid objects from tube when not being used.**
2. **Scour any accumulation or humps evenly over surface area of tube.**
3. **Concrete blocks or other weighted objects should be flexible bags or containers.**

On November 9, 2005, we were asked if the remaining geotubes could be folded so as to be placed on the second tier, pulled down by the use of two carts.

We submitted a suggested fold whereby the tubes would be accordion folded starting at one end. The ends were provided with four loop straps that were to be used to pull down and

position the tubes along the top of the base tube without requiring personnel to climb up onto that tube.

The damaged tube as shown in Schedule C was one of those tubes.

This tube should have been refolded or rolled to eliminate pulling over that surface.

Attachment 3

LFR OU1 2005 RA - Geotextile Tube Failure Photographs

No. 12 Failure - Facing South

No. 12 Failure - Facing West

Brad-1 Failure - Facing East

Brad-1 Failure - Facing South

B-11 Failure - Facing East

B-11 Failure - Facing Northeast

NEB-1 Failure - Facing East

NEB-1 - Facing South

BM-6 Failure - Facing West

BM-6 Failure - Facing East