Paste 2024 – AB Fourie & D Reid (eds)

doi:10.36487/ACG_repo/2455_23

Tailings storage: exploiting central thickened discharge for capping and closure

TG Fitton *Fitton Tailings Consultants, Australia*

Abstract

The idea of central thickened discharge (CTD) has been around for some 50 years since it was first conceived by Professor Eli Robinsky. The idea is based on the discharge of tailings slurry from an elevated point to form a conical mound, thereby avoiding the need for large dams to retain the tailings. Whilst the CTD has now been successfully used in more than 60 mines around the world to date, the use of the CTD for capping or closure of an existing tailings storage facility has only been applied a handful of times thus far. In particular, we refer to the placement of a CTD on top of an existing deposit of tailings for the purpose of creating a self-draining structure that is more efficiently and economically capped for closure of the tailings storage facility. This paper examines some of the cases where a CTD has been placed on top of an existing tailings storage facility, and discusses how some important challenges were overcome.

Keywords: *tailings, central thickened discharge, Robinsky, capping, closure, TSF*

1 Introduction

Tailings storage facilities (TSF) require closure and rehabilitation once they reach the end of their lives. This generally involves the placement of one or more layers of rock and/or soil on top of the exposed tailings to form a capping. This capping is generally expected to be contoured to create a final surface that will be free-draining to the surrounding area. The capping provides several important functions:

- It prevents tailings particles from being blown away from the TSF by strong winds.
- It prevents tailings particles from being washed away from the TSF by rainfall runoff.
- Its free-draining surface is expected to prevent rainfall from infiltrating into the tailings, as this will lead to unwanted long-term groundwater seepage from within the tailings impoundment.
- The capping also provides a trafficable surface for subsequent placement of top soil, and for revegetation of the area as part of its ultimate closure and rehabilitation to the environment.

The placement of a capping over a TSF can be difficult and expensive if the tailings are soft and weak. This is often the case with fine grained tailings (such as coal tailings, mineral sands slimes, oilsands tailings and uranium tailings). Capping placement can also be expensive if large volumes of soil or rock are required in order to achieve a suitable free-draining landform. Both of these scenarios provide drivers for exploiting Robinsky's concept of central thickened discharge (CTD) for capping.

The idea of CTD has been around for some 50 years since it was first conceived by Professor Eli Robinsky. The idea is based on the discharge of tailings slurry from an elevated point to form a conical mound, thereby avoiding the need for large dams to retain the tailings. Whilst the CTD has now been successfully used in more than 60 mines around the world to date, the use of the CTD for capping of an existing tailings storage facility has only been applied a handful of times thus far. The placement of one or more CTDs on top of an existing deposit of tailings will help to get the surface geometrically closer the self-draining structure that is that is desired for closure, and save on the cost of placement of capping fill. In situations where the stored tailings are soft, CTD capping can also be further exploited to improve the trafficability of the surface, and provide greater access for subsequent capping efforts.

This paper examines some of the cases where a CTD has been developed on top of an existing tailings storage facility, and discusses the drivers in each case, and some of the benefits realised.

Four TSFs will be discussed in this paper, all of which exploited Robinsky's central thickened discharge idea for various benefits.

2 Bulga Old Tailings Dam, New South Wales, Australia

Coal tailings from the Bulga Coal mine in New South Wales was the subject of an Australian Coal Industry Association Research Program (ACARP) research project in 2007 to investigate the impact of flocculant addition to coal tailings slurry (Bembrick 2008). Subsequent capping benefits were actually not part of the original project since secondary flocculation was relatively novel at the time and the researchers were more focused on the improvements in the stored tailings densities that could be achieved.

Following the encouraging results obtained from the ACARP flocculant trials, Bulga Coal mine decided to discharge secondary flocculated coal tailings onto the surface of the Old Tailings Dam (OTD), in an attempt to create a surface crust of superior strength to support subsequent capping efforts. The OTD was a conventional coal tailings storage facility with a tailings surface area of about 35 hectares, which had been filled with unflocculated tailings some 20 years earlier. This TSF had been sitting dormant for a decade while the mining company waited for the tailings to consolidate and gain strength but after all that time, the deposited tailings still exhibited extremely low shear strengths of less than 1 kPa in many areas. The cause of this very low strength was the very fine grain size of the stored coal tailings, which are notoriously slow to settle and consolidate.

In 2010, Bulga installed three vertical towers on the surface of the OTD and over the following three years, they discharged secondary flocculated tailings from each of the towers onto the existing tailings surface. Over time, this discharge created three conical shaped mounds on top of the previous tailings surface. In 2015, capping works commenced and by 2018, the whole TSF surface had been capped. A time series of aerial photographs of the OTD is presented as Figures 1 to 4.

Each of the mounds formed in a similar way to the build-up of a CTD but at this mine, the tailings slurry had not been thickened. Can this be called a CTD or should it be labelled a central flocculated discharge?

Figure 1 Aerial photograph of Bulga's OTD dated April 2007. This predates the tower installation

Figure 2 Aerial photograph of Bulga's OTD dated April 2012. The three conical deposits are visible

Figure 3 Aerial photograph of Bulga's OTD dated October 2013. The conical deposits are now quite large, and have flowed into one another

Figure 4 Aerial photograph of Bulga's OTD dated February 2017. The capping is almost complete

Figure 5 presents a view of one of the conical deposits, as seen from the edge of the TSF.

Figure 5 The uncapped eastern side of the eastern conical deposit on Bulga's OTD in December 2015. The discharge tower is the tall dark mast at the summit of the mound

3 Bullakitchie in-pit tailings storage facility, Granites gold mine, Northern Territory, Australia

The Bullakitchie in-pit TSF at the Granites gold mine in Australia's Northern Territory had an area of about 10 hectares and a maximum depth of about 70 m. It was filled with tailings from December 1996 through to January 1999, and the mining company decided to exploit Robinsky's CTD concept for the purpose of capping the existing tailings in the pit. The main driver for the use of the thickened discharge was the achievement of a free-draining final landform for closure, which would save on the cost of using rockfill material instead (Murphy 2007).

A layout drawing of the Bullakitchie in-pit TSF is presented as Figure 6, whilst a photograph of the tailings discharge point is shown in Figure 7.

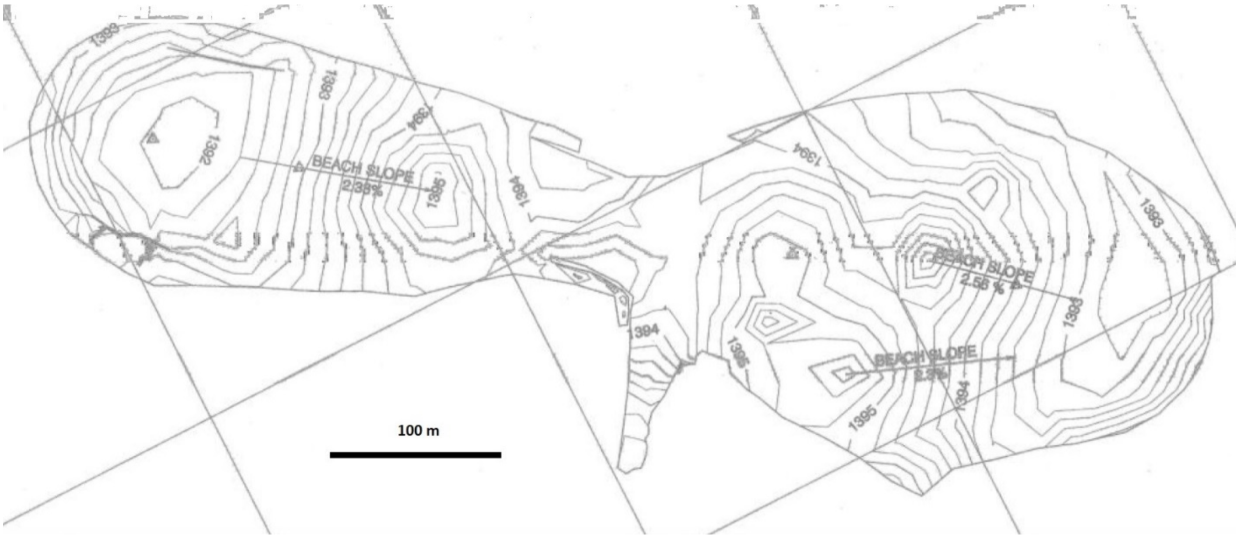

Figure 6 Plan of Bullakitchie pit (Murphy 2007)

Figure 7 The discharge point at Bullakitchie, which was tugged with a rope (Murphy 2007)

4 Talabre tailings storage facility (Chuquicamata copper mine, Chile)

The Talabre TSF at the Chuquicamata copper mine in Chile is the planned site of the world's largest CTD, which will be deposited on top of the existing conventional TSF. The Talabre TSF is about 12 km long and about 8 km wide, with a surface area of about 72 km^2. It is one of the largest TSFs in the world by surface area. The primary driver for the CTD project is the maximisation of the storage capacity of the Talabre TSF. This CTD will also provide significant savings during the closure of the Talabre TSF, as it will greatly reduce the amount of fill that will be required to cap the TSF with a free-draining surface.

During 2011, a series of flume trials were conducted at the mine with the primary purpose of testing the depositional behaviour of the tailings slurry at various concentrations and flow rates. A flow-through flume of 10 m length was constructed at the mine for this purpose. This flume is pictured in Figure 8.

Figure 8 The 10 m long flow-through flume that was operated at Chuquicamata (Fitton 2016)

In the years that followed the flume trials, a large-scale beaching trial was carried out on top of the Talabre TSF (Pirouz et al. 2015), which deposited a 500 m diameter CTD on top of the underlying tailings. An aerial photograph of the trial deposit is shown in Figure 9.

Figure 9 The trial area tailings deposit on the surface of the Talabre tailings storage facility

Since that time the detailed design of the new full-sized CTD has been prepared, and it is understood that the construction of the mechanical infrastructure is currently underway.

5 Musti tailings storage (Siilinjarvi phosphate mine, Finland)

The Siilinjarvi phosphate mine exploited the CTD to increase the storage capacity of their conventional upstream raised Musti tailings dam. The Musti TSF has been operating since 2003, and now covers approximately 420 hectares. Three conical mounds are currently being deposited on top of the existing tailings, which will enable the existing TSF to continue to serve the mine for an additional 18 years. The main driver for Siilinjarvi was to prolong the life of the Musti TSF (Fitton et al. 2018).

The CTDs will also provide significant economic benefits for the capping and closure of the Musti TSF once the TSF finally fills to capacity, by virtue of creating a tailings surface that will be more cheaply capped to achieve a free-draining landform, in comparison to having to construct the final landform using imported fill.

The Siilinjarvi mine is located in a cold climate that experiences freeze-thaw cycles. The tailings is also unusual as it is not only quite coarse with a d90 of 700 micron but also some 65% of the tailings particles are plate-like micaceous flakes. With these unusual conditions, a series of thickening trials and deposition trials were carried out at the mine in 2012–2014 to examine the performance of the thickener, pump and pipeline at higher slurry concentrations. During the trials, with some lower flow rates being tested, beach slopes up to 13% were observed. The author carried out the design for the CTD, predicting a slope of 6%. The actual slopes being achieved were found to be 6.1%.

A photograph of the tailings beach is presented as Figure 10 and an aerial photograph of the Musti TSF is presented as Figure 11.

Figure 10 The tailings beach at Siilinjarvi (Fitton et al. 2018)

Figure 11 Aerial photograph of Musti tailings storage facility dated June 2023. The three discharge points are located at the ends of the three causeways near the south-eastern corner of the TSF

6 Conclusion

Whilst Robinsky's CTD provides an excellent tailings storage solution in its own right, this paper has presented four cases where one or more CTDs has been placed on top of an existing tailings deposit to provide significant benefits. An obvious benefit is the ability to store significantly more tailings on the same footprint, as has been the case at Siilinjarvi, and which is expected to be the case at Chuquicamata too. A less obvious benefit is with capping, particularly where the underlying tailings is too weak to support mechanical capping efforts. This benefit was of significant value at the Bulga Coal mine. Finally, there is the capping scenario where a self-shedding landform is needed for closure, and a CTD can enable this process to take place with less cost and effort than mechanically placing rockfill or soil over a TSF. This opportunity was exploited in the Bullakitchie scenario.

Acknowledgement

The author wishes to thank Steve Murphy for input and guidance.

References

Bembrick, D 2008, 'The impact of flocculant addition on a tailings storage facility', *Metallurgical Plant Design and Operating Strategies*, pp. 541–549.

Fitton, T 2016, 'A hydraulically improved beach slope model', in S Barrera & R Jewell (eds), *19th International Seminar on Paste and Thickened Tailings*, Gecamin Publications, Santiago.

Fitton, TG, Henriksson, B & Ruhanen, E 2018, 'Designing the Siilinjärvi thickened tailings storage facility', in RJ Jewell & AB Fourie (eds), *Paste 2018: Proceedings of the 21st International Seminar on Paste and Thickened Tailings*, Australian Centre for Geomechanics, Perth, pp. 241–250, https://doi.org/10.36487/ACG_rep/1805_19_Fitton

Murphy, S 2007, 'In-pit tailings storage – a viable option', *Mine Tailings 2007*, Brisbane.

Pirouz, B, Javadi, S, Williams, P, Pavissich, C & Caro, G 2015, 'Chuquicamata full-scale field deposition trial', in R Jewell & AB Fourie (eds), *Paste 2015: Proceedings of the 18th International Seminar on Paste and Thickened Tailings*, Australian Centre for Geomechanics, Perth, pp. 477–489, https://doi.org/10.36487/ACG_rep/1504_37_Pirouz