Challenges and mitigation for Capacity augmentation of Tailing ponds

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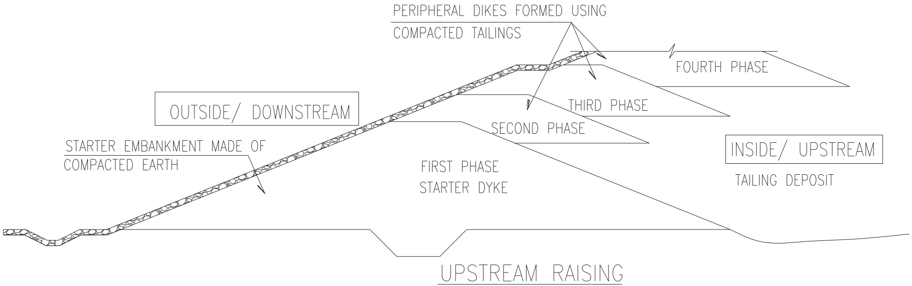
Beneficiation plant in the Iron mines separates contaminants & finescalled tailings from the ore. These tailings in a slurry form are generally disposed in a vast area of land encompassed by embankment called as tailing pond.Under the present socio-political scenario with limited availability of land,capacity enhancement by upstream raising of the height of the embankment made partly/ fully of the tailings/ mine wastes is apreferred option. This invites risk of slope failure of embankment because of soft tailinglayer in base unless proper engineering is done using appropriate technology for improvement of properties of the tailing layer. TCE has successfully mitigated this challenge by providing perforated vertical drains (PVD) and Geogrids.

The upstream raising of the embankment in a tailingpond envisages step by step construction of the dyke over a period on the upstream side, i.e. pond side. Initially raisingisdonepartly above the initial tailing deposit & partly above the starter dyke, and subsequently 4- 6m raising is done at each step. Thus the first stage of raising creates an additional storage space wherein tailing is further deposited till it reaches the maximum allowable height and then again a dyke is constructed in a similar fashion. This process isrepeated over the years till the design life of the pond.Since, in the upstream method dykes are constructed inside the pond, rate of increase of storage capacity decreases with each stage of raising. The downstream method of raising involves construction of the new dyke on the downstream side, i.e. on the outer side of the pond embankment and hence does notrest on the tailing deposit. But, for integration of the new dyke with the old dyke, benching/ key is formed on the downstream slope of the old dyke. This is a time taking job and quantity of fill for the embankment is also more. This method also occupies higher land space. Since, the dyke is constructed on the outer side of the pond, rate of increase of storage capacity increases with each stage of raising. The two methods are schematically represented in Fig. 1& Fig 2 respectively. Decision on the method of capacity augmentation of the tailing pond depends primarily on residual life of plant, mining plan and availability of land. Since, the upstream raising does not require extra land for capacity addition and requires less materials and construction time; - it is a preferable and economic solution for most of the old plants.



UPSTREAM RAISING

Fig. 1 Upstream method of raising

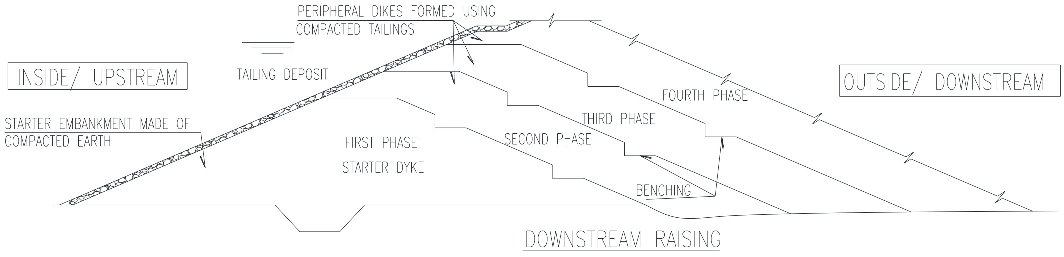


Fig. 2 Downstream method of raising

The upstream method of raisingenvisages embankment to be constructed over the tailings. However, for raising the height of embankment in this method, it is essential that adequate time gap between two successive raisings must be provided for consolidation of the tailings deposit and to achieve adequate bearing capacity. But, in most of the cases, schedule of mine planning is such that time gap in between two successive phases of height raisings do not permit adequate time for consolidation of the tailings as well as attainment of adequate bearing capacity to withstand further loads imposed on it. Hence, it is to be noted that though capacity addition by the upstream method of raising is a sustainable and preferred solution, it has an accompanying risk of failure also. The challenge can be successfully met by proper geotechnical investigation, analysis, use of appropriatetechnology and materials like PVDs and geogrids.

The present case is about capacity augmentation of an iron ore Tailing Pond spread over about 1500 hectares at a Project site in eastern India. The pond had already been in use over the past few years and the Owner planned to raise the height of the dyke by 3.0 meters. Upstream method of raising of the dykewas in progress when a slip circle failure at one part of the embankment occurred. Primarily mine waste materials were used for the construction work. Length of the failure zone was about 200 – 250 m. The failure pattern closely resembled with a classical slip circle having crest at around the mid-width of the embankment at top and toe towards the upstream side of the embankment. The failure associated movement of huge quantity of embankment mass and tailings within the pond which in turn created a heaving at some distance within the pond (Fig. 3).

Raising the height of embankment was undertaken after a short period of cessation of tailing disposal at the pond. Detail geotechnical investigation revealed that the underlying tailing deposit was very soft and undergoing the consolidation process at the time of raising the height. Tailings having low permeability and low degree of coefficient of consolidation was in a semi-viscous state with very low shear strength resulting to low bearing capacity. The bearing pressure due to loading from the embankment construction exceeded the bearingcapacity of the underlying tailing deposit leading to the failure.

The challenge was mitigated by adoption of the following steps:

- Determination of the total time available for implementing the preventive scheme and raising the height. This is guided by the mine planning activities and was decided in consultation with the Owner.
- Accelerating the consolidation to the required degree and time. This was achieved by proper design of prefabricated vertical drainage (PVD) system (Fig. 6).
- Assessment of the improvement in bearing capacity due to the installation of the PVD.
- Assessment of shortfall in the required bearing capacity with regard to improved bearing capacity.
- Providing Geogrid to augment the shortfall in the bearing capacity (Fig. 7).
- Detailing of the PVD & the Geogrid along with the other drainage layers.

A typical cross section of the engineering solution is shown in the Fig. 8.

From the above experience, it is pertinent to note that the upstream method of raising the height of the embankment is a sustainable way of augmenting the capacity of tailing ponds.However, a proper engineering of embankments using appropriate technology is a must to mitigate risks of failures and achieve faster construction without taking outage for the running plant.

The approach was successfully implemented by TCE for reconstruction of the embankment enabling the Owner to increase their tailing pond capacity with additional height of embankment by six metres beyond the originally envisaged heightof three meters (Fig. 9).

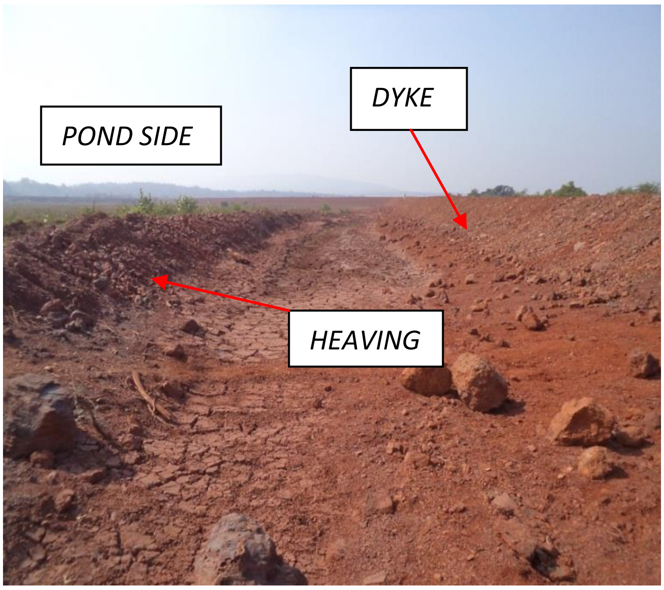


Fig. 3The embankment after failure; Heaving within the pond due to failure.

Fig. 4– Longitudinal crack in the embankment

Fig. 5– Sink hole in the embankment

Fig. 6 – PVD installation

Fig. 7 – Geogrid layingover sand layer

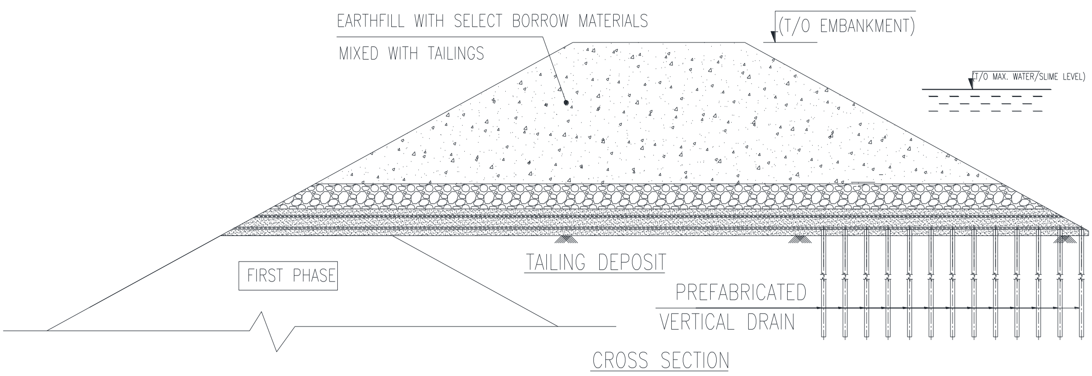


Fig. 8 – Typical Cross Section

Fig. 9 – Constructed embankment