Reinforced Earth® structures for headwalls to crushing plants in Africa

ACS Smith
Reinforced Earth (Pty) Ltd, Johannesburg, South Africa

ABSTRACT: The use of Mechanically Stabilized Embankments (MSE) for the construction of Head Walls and/or wingwalls to mine crushing plants in Africa is increasing. The advantages of MSE construction is that all material, except the locally available earth backfill, can be easily and efficiently shipped to remote locations in containers or break bulk on trucks and in aeroplanes. The structures are not sensitive to poor foundation conditions and consequently in most cases no special foundation preparation is required. No difficulty has been encountered in finding backfill conforming to standard MSE specifications. This paper describes the use of MSE for this application. It briefly describes various projects in several countries using precast concrete, steel and weldmesh cladding types.

1 INTRODUCTION

MSE structures were introduced into Southern Africa in 1975. The material rapidly found application for headwalls to crushing plants and numerous structures were constructed in South Africa, Namibia, Botswana, Lesotho and Malawi. After the end of South Africa's political isolation the use of MSE for headwalls spread to other more remote African countries such as Angola, Mali, Guinea and the Democratic Republic of Congo. A list of projects in Africa using the Reinforced Earth® system of MSE is given in Table 1.

2 APPLICATION

Crushing, screening and processing plants are gravity plants in which the ore is fed into the primary crusher at a height which could range between a few metres and 40 m from the bottom level of the plant. An earth ramp is required for the trucks to offload their ore. In order to prevent the earth ramp from enveloping the plant a headwall with associated wingwalls is required.

The headwall and the wingwalls can be constructed in MSE or alternatively, the headwall can be integrated into the crusher building and only the wingwalls are of MSE construction.

When Reinforced Earth® systems are used then a choice is made between 3 types of cladding viz.

- precast concrete cladding elements
- steel cladding elements with elliptical cross-section
- weldmesh cladding backed by rock or geo-fabric

The highest known straight up, non-tiered cladding on any structure to date is

- 38 m for steel cladding in Indonesia
- 27 m for precast concrete cladding in South Africa
- 18 m for weldmesh cladding in Australia

Higher walls are possible but, beyond a height of 15m, say, the cladding should be stepped, even if only a distance of 300 mm, in order to relieve stress in the cladding due to internal settlement of the backfill both during and after construction.

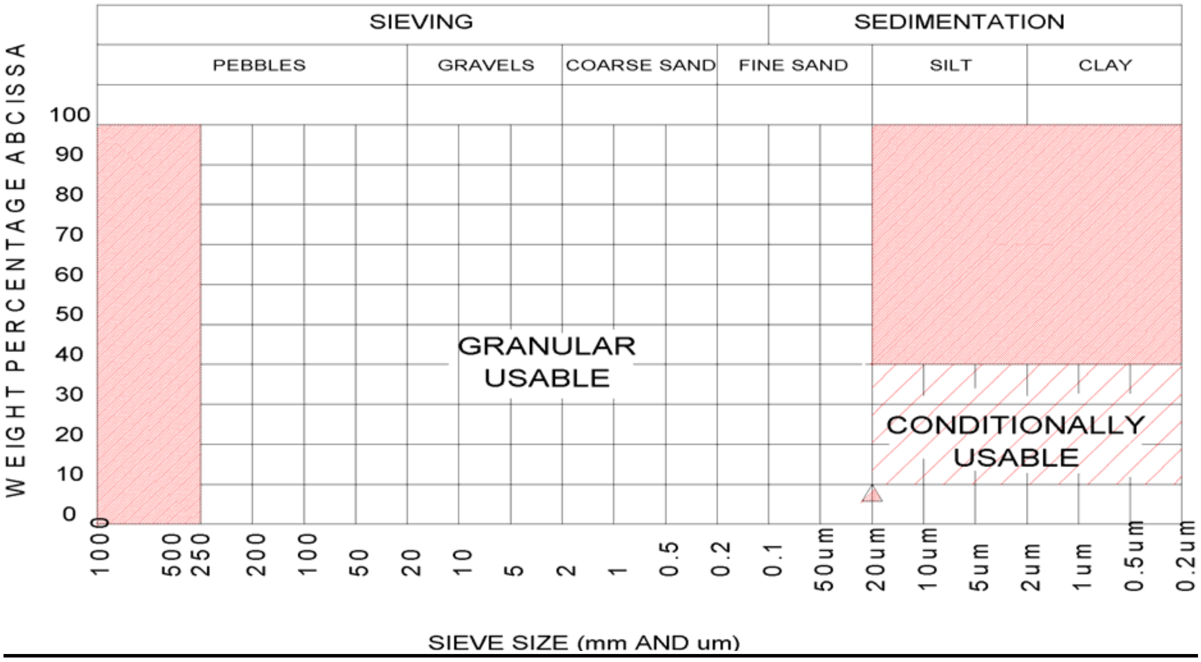
These systems are illustrated in the examples given in Figs 2, 3, & 4.

A slab, generally of reinforced concrete, with an upstand at the front is constructed on top of the MSE structure. The purpose of this slab is to

- provide an all-weather riding surface
- distribute the wheel loads of what could be very large vehicles
- provide a kicker against which trucks can reverse in order to tip.

Table 1. Summary of MSE Tipwalls – Reinforced Earth ® systems only

Date	Name	Location	Description	Max Height m	Type of cladding	Client
1976	CDM - 50G	Namibia	Headwall	20	Concrete	De Beers
1976	Grootegeluk	Ellisras NP	Wingwalls	20	Concrete	Iscor
1976	CDM No 3	Namibia	Headwall	13	Concrete	De Beers
1976	Silicon Smelters	Pietersburg NP	2 Tier Headwall	16,5	Concrete	Silicon Smelters
1977	Beestekraal I	NW Province	Headwall	8,3	Concrete	PPC
1977	Koingnaas	NW Cape	8 Tiered Wingwalls		Concrete	De Beers
1978	Kimberley I	Kimberley NW	Wingwalls	6	Steel	De Beers
1978	Jwaneng I	Botswana	Headwall	6,7	Steel	De Beers
1979	Tweepad	NW Cape	Wingwalls	2Tier 41	Concrete	De Beers
1979	Machadadorp	E Transvaal	Headwall	6	Concrete	S A R
1979	Beestekraal II	BeestekraalMine	Raise Headwall	3	Concrete	PPC
1979	Jwaneng II	Botswana	Headwall	8	Steel	De Beers
1979	Kimberley II	NW Cape	Headwall	7	Steel	De Beers
1979	Marquard	Free State	Headwall	6	Steel	RG Nuttall
1980	Aggenuys	NW Cape	Headwall	13	Concrete	Goldfields
1982	Rooikraal	Gauteng	Headwall	13	Steel	D& H
1982	Silicon Smelt II	N Province	Headwall	6	Concrete	Silicon Smelters
1983	Fairview	Mpumalanga	Headwall	6	Concrete	Gencor
1985	NCD	Kwa-Zulu Natal	Wingwall	6	Steel	N C D
1986	Wastetech	Gauteng	2 Tier Headwall	8	Steel	Wastetech
1986	Tweepad II	NW Cape	Wingwalls	2 Tier 41	Concrete	De Beers
1987	Wolwekrans	Mpumalanga	Headwall	7,5	Concrete	Rand Mines
1987	Koffiefontein	NW Cape	Headwall	7	Steel	De Beers
1987	Grootegeluk II	N Province	Wingwalls	2 Tier 25	Concrete	Iscor
1989	Auchas	Namibia	Headwall	6	Concrete	De Beers
1989	Samadi Mine	NW Province	Headwall	13,5	Concrete	Samadi Mine
1989	Premier Mine	Gauteng	Headwall	12	Concrete	De Beers
1990	SavmoreColliery	Kwa-Zulu Natal	Headwall	8,3	Concrete	Genmin
1990	Weltevreden	NW Province	Headwall	10,5	Concrete	Genmin
1991	Dull Coal	N Province	Wingwalls	24	Concrete	Iscor
1991	Lone Rock	Mpumalanga	Headwall	6	Weldmesh	Lone Rock
1991	Auchas II	Namibia	Headwall	14	Concrete	De Beers
1991	Sasol 1 Tip	Free State	Headwall	5	Concrete	Sasol
1991	Kromdraai	Mpumalanga	Wingwalls	15 of 25	Concrete	AAC
1992	Luzamba	Angola	Headwall	11,4	Weldmesh	Endiama
1993	Sigma	Free State	Headwall	6,8	Concrete	Sasol
1994	Duvha	Mpumalanga	Wingwalls	13	Concrete	Eskom
1995	Sadiola Mine	Mali	Wingwalls	16	Weldmesh	AAC
1996	Catoca	Angola	Headwall	10,5	Concrete	Endiama
1997	Siguiri Mine I	Guinea	Headwall	13	Concrete	Ashanti
1998	Orapa	Botswana	Wingwalls	16; 10 Sur	Concrete	De Beers
1998	Namakwa Sands	SW Cape	Headwall	10	Concrete	Namakwa Sands
1998	Lethlekhane	Botswana	Wingwalls	2 Tier 20	Concrete	De Beers
1998	Congo	DR Congo	Headwall	12	Steel	Miba Mine
1998	Siguiri Mine II	Guinea	Headwall	14	Concrete	Ashanti
1998	Kroondal	NW Province	Headwall	13,5	Concrete	Kroondal
1998	Bulyanhulu	Tanzania	Headwall	11,7	Weldmesh	Placer Dome
1998	Samancor	Gauteng	Headwall	9	Concrete	Samancor



Chemical and Electro-chemical Properties		
	Out of water	In Water
Resistivity (ohm mm)	≥ 10 000	≥ 30 000
Ph	5 to 10	5 to 10
Chlorides (ppm)	< 200	< 100
Sulphates (ppm)	< 1 000	< 500
Sulphides (ppm)	< 300	< 100

Figure 1. Material suitable for use in MSE structures

3 BACKFILL

The backfill required for the MSE structure should meet the mechanical and electro-chemical requirements shown in Fig 1. The African continent presents the full range of potential backfill materials. Since the service life of structures is generally only 30 years or so, backfills more permanent structures may be considered. Backfill may be categorized into 4 groups.

3.1 The Best

- Free draining sands or gravels ie < 5% by weight passing the 75 micron sieve.
- Mine waste rock or tailings, provided it has not become polluted in the process.

3.2 Good

- Granular material according to Fig 1. either
from transported material or weathered residual rock.

3.3 Satisfactory

Intermediate materials according to Fig 1. These materials are water sensitive and local deformation and bulging of the face due to post construction settlement and excess pore water pressure should be anticipated.

- Lateritic gravels, pebble markers.

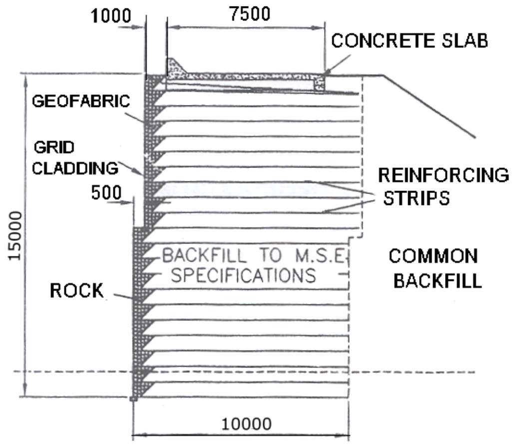


Figure 2a. Typical cross section – Sadiola Gold Mine, Mali

3.4 Unacceptable

- Material with grading falling outside that shown in Fig 1. such as silts and clays.
- Organic material

Care should be taken when using :

shales - they may deteriorate when exposed to the atmosphere

rocks - which, oxidize when in contact with air or water, producing aggressive groundwaters.

The experience to date is that backfill materials are readily found near the Site. It is advisable to use good quality backfill for structures higher than say 12 m.

4 ADVANTAGES OF MSE FOR THIS APPLICATION

- An MSE structure is a flexible one and can absorb some differential settlement. This means that an MSE structure is not particularly sensitive to the nature of the foundation and can be founded on relatively poor foundations without the need for any foundation improvement. Should foundation improvement be required, however, then undercutting and replacement with good quality compacted backfill to the underside of the MSE structure should suffice. On the other hand piling may be required for a more rigid structure such as a reinforced concrete one.
- Local backfill can generally be found to meet the specifications.
- All materials except the earth can be supplied in containers to far-away and remote locations. The cladding and strips are not bulky and are sized to fit into containers. Should 20 ft containers be used then the longer length reinforcing strips can be cut and punched at both ends and spliced together into the longer lengths on site with fish plates and bolts.

Figure 2b. Weldmesh cladding backed with rock – Sadiola Gold Mine, Mali

Figure 3a. Elliptical steel cladding - Miba Mine, Democratic Republic of Congo

Figure 3b. An example of a steel cladding wall as used at Miba Mine above .

Should precast concrete cladding walls be required, then the moulds, inserts, reinforcing strips and jointing material can be supplied in containers and the panels precast on site.

- No special skills are required for the construction and local labour can readily be used.
- The construction of the approach ramp can be planned to be built at the same time as the headwall structure. This results in time savings and allows the earthworks contractor to finish off the earthworks in one period of time. The bulk earthworks for headwalls is often undertaken by the Mine itself with

Figure 4. Precast concrete cladding – Siguiri Mine, Guinea

massive earthmoving equipment and little compaction control. The interface between the Mine bulk earthworks and the formal layers and densities required for the MSE structure need to be carefully managed. If sufficient attention is given to this then considerable time and cost savings can be realized.

- An advantage, on occasion, is that no aggregate is on site at the time that the headwall is constructed. It may be the headwall for the aggregate plant. In this case steel or weldmesh cladding is an ideal system since only local labour and earthmoving equipment is required.

5 CONCLUSIONS

- MSE walls have proven themselves to be able to meet the technical requirements for headwalls and to be cost effective. They utilize local earth, labour and earthmoving plant to construct headwalls quickly, easily and efficiently.
- Careful control is however required to coordinate the Mine and the Contractor and to ensure that the structures are built according to the drawings and specifications.
- Africa is a mining continent and a considerable number of headwalls and/or wingwalls are required. MSE walls should be considered for these applications.