water affairs
Department:
Water Affairs
REPUBLIC OF SOUTH AFRICA

K. Legge/K Mnisi/C Ficker
Tel: 012 336 8677/8944/6656
Ref: 16/2/7/A220/C7

CHIEF DIRECTOR: REGULATION

For attention: Ms W Moolman and Ms M Mahlhalha

WUL AND NEMWA WASTE LICENCE: ESKOM: KUSILE POWER STATION: COAL STOCKYARD LINER DESIGNS

1. Presentation

On Monday 2 September 2013 at 08h00 the project background and detail were presented by Mr L Stapelberg of Kusile PS and Mr I Hammond of SRK Consulting Engineers at an extra-ordinary meeting (see attendance register).

2. Documentation

The following document was presented:
a) Summary document addressing barrier system to be employed in the live; seasonal; and strategic coal stockyards.

3. Consideration

The design engineer has considered the discussion of the February 2013 scheduled meeting and in response proposes a barrier system from the bottom upwards of: compacted in-situ material; a GCL with performance at least equal to 600mm of specified clay; a geomembrane of 1.5mm thickness HDPE; two layers of geotextile for protection and drainage with anticipation of the upper layer becoming blocked by concrete, followed by a 175mm thick reinforced concrete slab. In certain areas of the solum sub-surface drainage will be required which will be given effect by the use of wick drains leading to horizontal drains beneath the foundation preparation layer. The wick drains will be geosynthetic (geotextile wrapped drainage net) and lead to granular horizontal drains, for which detail is awaited. This horizontal granular drainage in lieu of horizontal geosynthetic drains is to overcome creep collapse considerations of geonets (such as Netlon).

The upper geotextile layer (Bidim A6) may be replaced with a pioneer layer of soil being sand with some cohesion and a minimum thickness of 100mm or as required by the designer.

The Engineer recognised interface shear and confirmed the structure to be stable for the designed layout he presented.

4. Recommendation

It is recommended that the design be accepted in principle with details to confirm the above on signed drawings to be received prior to deposition of coal. It is also recommended that construction be allowed to continue on these facilities provided neither waste nor product is stored prior to sign off in accordance with the NEMWA regulations 2013.

ACTING CHIEF DIRECTOR: ENGINEERING SERVICES
Letter signed by KR Legge
Chief Engineer: Integrated Environmental Engineering
Date 04/09/2013

Name	Company	Contact No.	E-mail	Signature
Kelvin Legge	DWA		leggek@dwa.gov.za	
Claire Fricker	DWA	012 336 6656	frickerc@dwa.gov.za	
Keith Mnisi	DWA	012 336 8944	mnisikk@dwa.gov.za	
IAN HAMMOND	SRK	011 441 1111	ihammond@srk.co.za	
PAMIE VENTER	SRK	011 441 1111	dventer@srk.co.za	
Wilna Moolman	DWA	082 804 4830	moolmanw@dwa.gov.za	
Tinus Breedt	KET	082 344 3441	chromtechindustrial.com	
[illegible]	KET	082 967 5927	[illegible]	
TRAVIS D GEE	KET	011-760-5343	geetd@bv.com	
Oo Charles	KET	071 860 0363	Charlesde@BV.com	
Willie vd Heever	KET	0833068101	vdheeww@sita.co.za	

srk consulting

SRK House
265 Oxford Road
Illovo 2196
P O Box 55291
Northlands 2116
South Africa
T: +27 (0) 11 441 1111
F: +27 (0) 11 880 8086
E: johannesburg@srk.co.za
www.srk.co.za

18 August 2013
463129

Eskom Holdings SOC (Pty) Ltd
EED – Civil Engineering
Chief Engineer
Eskom Enterprises, Building 3
Sunninghill
South Africa

Dear Sirs

REPORT ON REVISED LINER DESIGN AT KUSILE COAL STOCKYARD

1. Introduction and scope of report

On 08 May 2013 SRK received an appointment from the Umbani Joint Venture to undertake a re-design of the Kusile Coal Stockyard liner system. This was necessary following Department of Water Affair's (DWA) rejection of the previous designs for the coal stockyard lining system.

A meeting was held with DWA on 13 February 2013 where the liner design at that time was discussed. DWA ENGINEERING SERVICES (DWA-ES) indicated in letter reference 16/2/7/A220/C7 addressed to the CHIEF DIRECTOR: WATER USE that a concrete lined facility would be deemed acceptable for the live, seasonal and strategic stockpiles as protective working surfaces. This letter further confirmed that a revised/final design would be submitted to DWA-ES for consideration. The above SRK appointment by Umbani Joint Venture was made to develop the design so that the re-submission to DWA could be made, and to complete the approved design to Issued for Construction drawings.

In terms of the appointment, initial design sketches were submitted to Eskom's Kusile Project Manager, Black and Veatch (B&V), on 14 June 2013. These design sketches were reviewed by Jones and Wagener (J&W) and comments were received. A meeting was held with J&W, Eskom, B&V and SRK on 08 July 2013, during which the design concepts were communicated by SRK, and J&W's review comments were discussed. A final review document issued by J&W was forwarded to SRK by B&V on 31 July 2013.

SRK then developed the lining system described in this report.

A meeting was held on 01 August 2013 to discuss the Kusile CSY liner design. This meeting was attended by Eskom, B&V, and SRK. This meeting also (inter-alia) addressed certain aspects of the Medupi CSY design which (conceptually) is similar to the Kusile liner design.

This report addresses the purpose of the design, the design criteria used, the liner configuration used in the design, and the constructability of the facility. The J&W review comments are also addressed.

1.1 Purpose of the design

The purpose of the design is to provide a barrier which meets the regulatory requirements regarding the ingress of water from the Kusile Coal Stockyard stockpiles into the ground which withstands the live and long term loads of the coal stockyards, and which provides a durable protective working surface for the 60 year life of the facility.

2. Design criteria

2.1 Coal geotechnical parameters and concrete slab design

The following design criteria are used for the Kusile CSY stockpile liner designs.

			Source
Coal criteria			
Angle of repose	degrees	45	F Louwinger e-mail 06 March 2013
Internal friction angle	degrees	35	F Louwinger e-mail 06 March 2013
Seasonal and live stockpiles:			
Wet bulk density	kg/m3	1 100	Used in Medupi design. Not specified for Kusile.
Minimum bulk density at toe	kg/m3	900	F Louwinger e-mail 06 March 2013
Maximum bulk density in the middle	kg/m3	1 250	F Louwinger e-mail 06 March 2013
Moisture content	%	12	Used in Medupi design. Not specified for Kusile.
Strategic stockpiles			
Design density	kg/m3	1 440	F Louwinger e-mail 06 March 2013
Maximum stacking height - seasonal and live	m	15.345	Coal Stockyard EPCM contractor (Bateman) drawing.
Maximum stacking height – strategic stockpile	m	17.00	Eskom BMH personnel
Stacking method is chevron only - seasonal and live			Discussions with Eskom BMH personnel.
FOS against failure		1.3	Required by Eskom for the Medupi design. Not specified for Kusile.
Concrete slabs			
Designed as watertight concrete			Per Kusile Power Station Specification for Structural Concrete document number 203-770 Revision 04 dated 20 October 2009
Top cover required 80mm			Per Kusile Power Station Specification for Structural Concrete document number 203-770 Revision 04 dated 20 October 2009: "Surfaces exposed to aggressive discharges".
Crack widths < .004 x cover			Required by Eskom for the Medupi design. Agreed with Eskom for the Kusile CSY slabs in the 01 August 2013 meeting.
Crack width maximum 0.2mm			Per Kusile Power Station Specification for Structural Concrete document number 203-770 Revision 04 dated 20 October 2009
Joints			
Diamond plate expansion joints			Required by Eskom for the Medupi design. Not specified for Kusile.
No saw cut joints			Due to watertight concrete requirement and to prevent corrosion of the reinforcing.

2.2 Effluent discharge

To meet the regulatory requirements the design criteria agreed with the project team are:

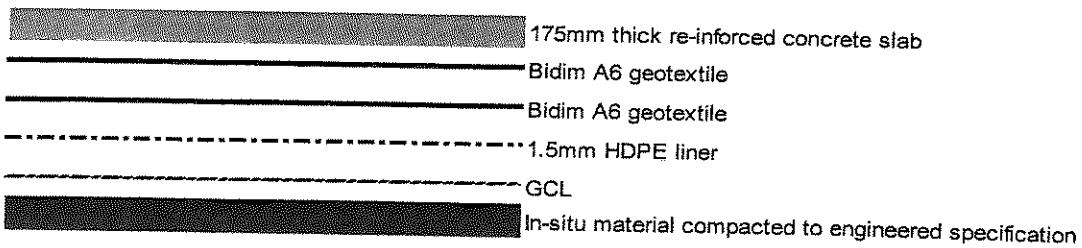
- The coal stockyard facility should be a zero liquid effluent discharge (ZLED) site under normal climatic conditions and all dirty run-off and seepage water will be contained in the dirty water dam. The dirty water dam is designed by others.
- The coal stockyard terrace will be lined with a geomembrane (or similar approved method) to prevent water ingress into the foundations.

2.3 Geomembrane protection

To comply with a design that would be considered by DWA-ES, it was agreed with the team to design concrete slabs over the live, seasonal and strategic stockpile liners. The concrete slab protects the liner from mechanical damage from mobile equipment and reclaiming operations.

2.4 Liner design

To meet the regulatory requirements for zero liquid effluent discharge, and to provide an adequate protective working surface to the liner, the following liner configuration was designed:



2.5 Layers

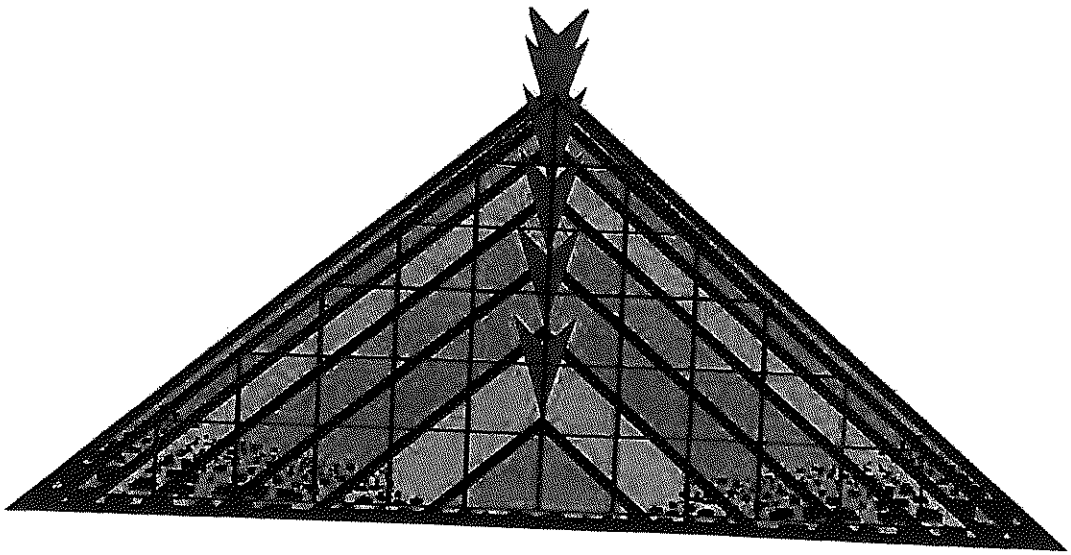
The layers and their respective functions are:

- 175mm concrete: This will be 35MPa concrete with 80mm cover on top and 75mm cover at the bottom. This acts as a tension member foundation as well as a protective surface to avoid damage to the liner during operation of the stockpiles. It is designed as a watertight concrete structure to prevent cracking and subsequent corrosion of the reinforcing steel.
- Top Bidim A6 geotextile. This acts to prevent concrete fines penetrating the second Bidim A6 geotextile during construction. It also functions to protect the underlying membranes during construction activities.
- Second Bidim A6 geotextile. This acts as a zero pressure drainage layer above the liner. It daylights into the storm water system at the inner edges of the stockpile.
- 1.5mm smooth HDP liner. Primary barrier
- GCL. Secondary barrier, equivalent to a 600mm clay layer.
- Compacted engineered soil/sub-base suitably designed for bearing capacity.

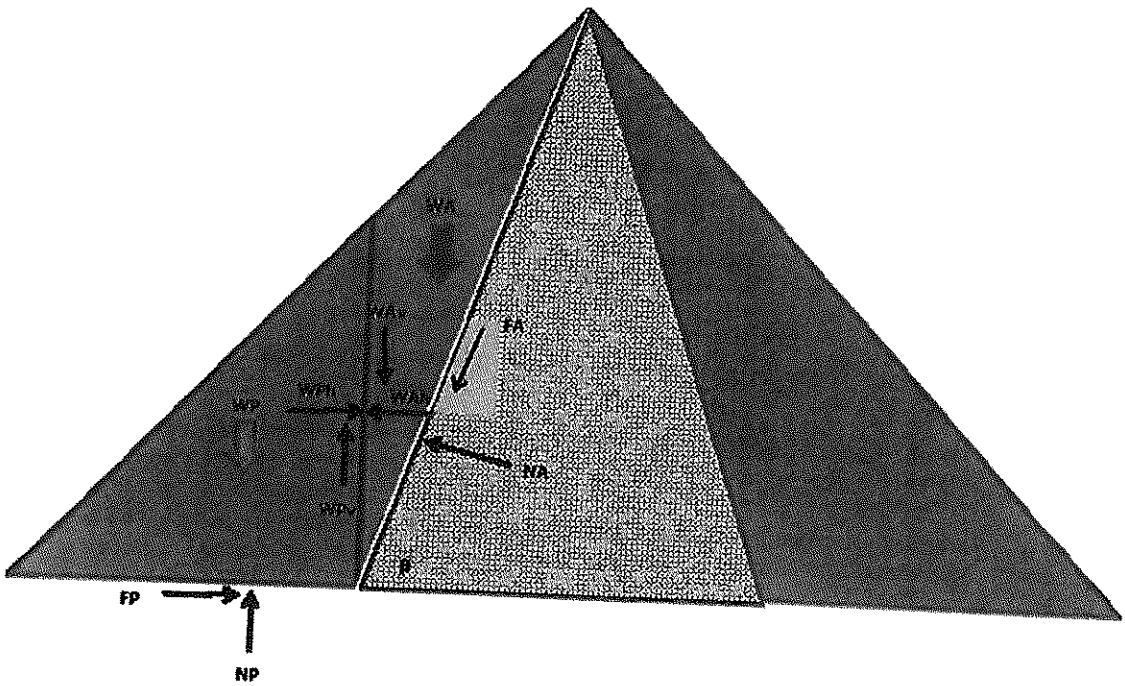
2.6 Concrete structural design

2.6.1 Lateral tensile forces in the concrete slabs

The stockpiles will be loaded from a centre point in a chevron pattern. This is shown in the diagram below:



The stockpiles are stacked at the coal angle of repose of 45° depending on the apparent cohsion developed mainly due to the moisture content of the coal This is steeper that the internal friction angle of 35°. Due to the equilibration of the internal forces in the coal pile, a net tension is developed in the underlying foundation, which in the case is the concrete slab. A diagram showing the forces necessary to maintain the stacking angle are show below. The tension in the slab must correlate to FP shown so that the stockpile heap is in equilibrium.



Since the concrete is a stiff member with low strain compared to either the coal, the HPDE/GCL liner of the foundation, the fully developed lateral force results in tension forces in the concrete, without shedding load via shear to the substrate.. These tension forces were determined using both translational failure (shown above) and finite element analyses. The maximum tensile force in the reinforced concrete liner is 510kN/m for the given coal geometric criteria

To withstand the tension forces in the concrete, the concrete will be continually reinforced throughout the length of each panel, with most reinforcing in the centre of the facility where the forces are the greatest. The slabs do not butt up against the longitudinal edge beams and the shear forces are therefore not transferred as lateral forces to the edge beam. The horizontal tension forces in the concrete are therefore taken up internally by the reinforcement, and no shear is transferred to the liner as a consequence of strain compatibility . Normal forces (NP above) are transferred through the concrete and liner fabrics to the underlying foundations. Because there are no tensile forces in the plastic liners, there is no creep under constant or intermittent load, and hence the system will be stable.

As the concrete is designed as a water retaining structure, no saw-cut joints are specified. The maximum crack width has been determined to be less than 0.2mm.

The concrete panel sizes are specified at 40m x 10m in the seasonal and live stockpiles, with similar maximum sized panels for the strategic stockpiles. These panel sizes equate to $70m^3$ per panel, which allows for two panels to be comfortably cast per shift using a standard concrete batching plant. The panel size will be evaluated based on feedback from the construction contractor.

2.6.2 Longitudinal forces in the concrete slabs

As the slabs are loaded and unloaded, the same forces develop as is shown in the above translational forces diagram. The reinforcing in this direction is equivalent to the reinforcing in the orthogonal direction.. This will be reviewed in the detailed design phase.

2.6.3 Structural stability for the strategic stockpile

The final stacking angle of the strategic stockpile is flatter than the live and seasonal stockpiles. This means that the tension forces generated because of the flatter slope are less. There is however the possibility that the stacking and unloading operations will result in steeper slopes, and the reinforcement is therefore the same as for the seasonal and live stockpiles. The strategic stockpile will be built with adequate edge beams all around, and hence it is possible to have joints in both directions.

2.6.4 Live loads

The seasonal and strategic stockpiles are both unloaded using heavy front end loaders (Cat 988 or equivalent), but requires to be reviewed in the final design. The strategic stockpile has also been designed for live loading of the stockpile. The slab designs have been checked for both the normal and shear forces arising during from the loading and unloading operations and the design is suitable. Since the live stockpiles may also be unloaded mechanically at some time during the design (as there is equipment access to these stockpiles from the ends) the above check is adequate for these slabs.

3. Alternative liner strengthening and protective working surfaces

Various alternative designs were put forward by a number of parties, and these were considered as follows:

- Roller Compacted Concrete. While this would provide a suitable working surface, the concrete will still need to be reinforced to be able to withstand the tension loads. SRK has determined that these loads cannot be transferred into the liner (exceeds the tensile strength of the liner) or through the liner (exceeds the internal shear strength of the liner) as would be the case with un-reinforced concrete. This was therefore not considered as an option.
- Concrete filled Geocells. The above statements regarding unreinforced concrete apply. In addition, SRK considers the discrete concrete blocks associated with Geocells to be a potential individual punch item that may puncture the liner. This was therefore not considered as an option.
- Plastic Geogrid reinforcing. Although this would provide an economic solution in terms of speed of construction, it will not provide a wearing surface for consideration by DWA-ES, and may also be subject to short and long term creep deformations and is therefore unsuitable as a foundation member. This was therefore not considered as an option.

4. Stockpile drainage design

4.1 Stockpile surface water

Surface water from the stockpiles will be directed to dirty water channels around the strategic stockpile perimeter, and off the seasonal and live stockpiles to channels that discharge to the dirty water under-drainage system. These dirty water channels and pipe systems ultimately discharge into the dirty water dam. The dirty water dam is beyond our battery limits and is designed by others.

4.2 Stockpile seepage water

Recharging of the water into the stockpiles from rain is expected to be minimal. Following severe storms, the penetration of a wetted front into existing stockpiles has been observed to be about 75mm maximum. This is attributed the speed of water discharge off the facility for the seasonal and live stockpiles, and the compacted density of the coal in the strategic stockpiles. In the event that water is allowed to pond on strategic stockpiles, or the coal placed in the strategic, live or seasonal stockpiles arrives wet, then the water in the coal will need to be removed at the outer toe of the respective stockpile.

To facilitate this, the concrete slopes towards the outer channels of each stockpile (1:100). The flow within the stockpiles still needs to be modelled and assessed as part of the final design, and if necessary a layer of coarser coal will be placed over the concrete surfaces as a pilot layer to facilitate drainage. This may need to be replaced a few times over the life of the facility.

4.3 Groundwater pressure under the strategic stockpile liner

In the area where the strategic stockpile was cut into the natural ground, i.e. where the terrace is now below the prior natural ground level, water pressure will be relieved. Flat pressure relief drains will be installed under the GCL/HDPE composite liner which will tie into a clean water sub-soil drain system. These will lead to a cut-off sub-soil drain to be installed around the eastern perimeter, and which will drain towards the clean water systems north and south of the coal stockyard. The spacing and drain specification will be specified during the final design stage.

4.4 Constructability

4.4.1 Jones and Wagner review meeting

At the 08 July 2013 meeting attended by Jones and Wagener (Danie Brink and Anton Bain), Eskom (Willie van den Heever, Tinus Breedt, et al), Black and Veatch (Travis Gee) and SRK (Ian Hammond), the need for a relatively heavily reinforced concrete slab over the liner and the requirement for no lateral form of joints (saw-cuts, expansion joints etc) was discussed.

Jones and Wagner commented on the constructability of the coal stockyard. It was suggested by Jones and Wagener that a sand layer be placed between the liner and the concrete to prevent bubbling of the plastic, and to provide a zero pressure drainage layer on top of the liner. SRK reviewed the requirements for the sand drainage layer, and determined that a second geotextile layer would be more economic than the sand, and that construction can be timed so that the concrete is placed when the liner is coolest with no expansion bubbles forming (i.e. nighttime). It was therefore decided not to incorporate the sand drainage layer.

4.4.2 Eskom constructability meeting

A second constructability meeting was held at Eskom on 01 August 2013. This meeting was for both the Medupi and the Kusile liner systems, as the designs are conceptually similar. SRK noted in this meeting that the width of the panels can be adjusted to suit the contractor's requirements for access and speed of construction.

4.4.3 Contractor review

Prior to the Kusile appointment, the constructability of the Medupi system was reviewed with the contractor that is appointed to install the Medupi liner and concrete protective working surface. A similar review will need to take place with the appointed Kusile contractor. The following was agreed in the contractor reviews:

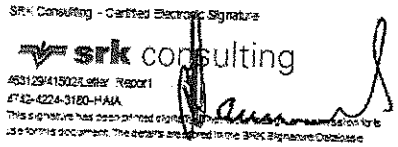
- The panel width can be adjusted to accommodate the contractor's preferred method of construction, as well as the width of the liners, leaving enough room for welding of the adjacent liner.
- This concrete placement will need to be done at night to prevent bubbling of the liner. The weight of the reinforcing will also prevent bubbling.

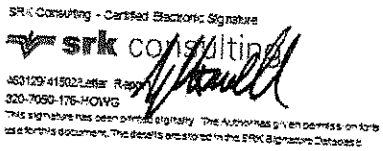
- The reinforcing has been designed to be pre-assembled outside of the lined area, and craned in as necessary. This is aimed at maintaining the integrity of the liner.
- Appropriate spacer blocks are to be used on the reinforcing to prevent damage to the liner.. These will be approved as part of the contractor's method statement.
- The liner can only be installed just prior to construction. This will prevent trafficking over the liner during construction of the adjacent concrete panel, and will allow for appropriate formwork to be used without damage to the liner.

Please contact the undersigned should there be anything further requirements.

Yours faithfully,

SRK Consulting (South Africa) (Pty) Ltd





Ian Hammond Pr Eng
Corporate Consultant

Graham Howell Pr Eng
Partner