OCEANIA TASMANIA

COMSTOCK MINE CENTRAL WASTE DUMP: SUMMARY OF GEOTECHNCIAL ASSESSMENT OF CAPPING

Zeehan, Tasmania

Z13095/2-AE

22 June 2004

Z13095/2-AE BMcD
22 June 2004

Oceania Tasmania
65 Murray Street
HOBART TAS 7000

Attention: Mr Paul Heath

Dear Sir,

RE: COMSTOCK MINE CENTRAL WASTE DUMP: SUMMARY OF GEOTECHNCIAL ASSESSMENT OF CAPPING

We are pleased to present our summary report of the geotechnical assessments carried out on the waste dump capping constructed by Oceania Tasmania between February 2002 and April 2004.

Please do not hesitate to contact the undersigned if you require any further assistance.

For and on behalf of

COFFEY GEOSCIENCES PTY LTD

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1. INTRODUCTION

During the period between March 2002 and April 2004, representatives from Coffey Geosciences Pty Ltd (Coffey), made several site visits to the Oceania Tasmania Pty Ltd's Comstock Mine in Zeehan Tasmania. The purpose of these visits was to provide a continual assessment on the clay cap and emplacement process on the Central Waste Dump (CWD) of the mine. The assessments are based on general field observations, engineering logs of test pits dug through the cap material and on push-tube samples taken for laboratory testing of insitu moisture content and density.

The purpose of this report is to present a summary of the findings and discussion provided in each of the individual progress reports presented to Oceania Tasmania.

Four site visits were conducted on the dates shown below producing the following reports (title and reference number):

1. 1st of March 2002
    - 'Central Waste Dump Assessment of Trail Capping'- (Z13095/1-AA)
    - 'Central Waste Dump: Results of Laboratory Testing of Trial Capping Materials' – (Z13095/1-AC)
2. 25th of February 2003
    - 'Central Waste Dump: Results of Site Visit and Laboratory Testing'- (Z13095/2-AA)
3. 20th of June 2003
    - 'Central Waste Dump: Results of Site Visit and Laboratory Testing' – (Z13095/2-AB)
4. 26th of April 2004
    - 'Central Waste Dump: Results of Laboratory Testing, 4th of may 2004'- (Z13095/2-AC)

2. SUMMARY OF FIELD VISIT OBSERVATIONS AND LABORATORY TEST RESULTS

2.1 Summary of Laboratory Test Results and Test Pit Logging

The results of test pits and laboratory testing of samples are summarised in Table 1 below. The approximate locations of test pits is shown on Figure1.

Table 1. Summary of Capping Test Pits and Laboratory Test Results

Site Visit	Test Pit	Material Type	Cap Thickness (m)	Moisture Content (%)	Dry Density (t/m^3)	Degree of Saturation (%)
1/3/02	1a	Grey Gravely Clay	0.35	-	-	-
1/3/02	2a	Grey Gravely Clay	0.60	35.3	1.47	85
1/3/02	3a	Grey Clayey Gravel	0.70	-	-	-
1/3/02	4a	Green-grey Gravely Silt/Clay	0.65	30.8	1.51	78

1/3/02	5a	Green-grey Gravely Silt/Clay	0.70	-	-	-
1/3/02	6a	Green-grey Gravely Silt/Clay	0.70	36.7	1.36	80
25/2/03	03/1	Grey Gravely Silty Clay	>1	35.4	1.35	77
25/2/03	03/2	Grey Gravely Silty Clay	>1	33.2	1.40	75
25/2/03	03/3	Brown Grey Sandy Silt, with coarse root organics.	>1	64.9	0.94	105
20/6/03	1	Green grey and orange Gravely Silty Clay	1.3	44.3	1.26	89
20/6/03	2	Green grey Gravely Silty Clay	1.3	39.6	1.30	82
20/6/03	3	Green grey Silty Clay	1.4	59.1	1.02	100[1]
20/6/03	4	Grey and orange Gravely Silty Clay	1.3	55.3	1.07	97[1]
20/6/03	5	Grey and orange Silty Clay	1	51.2	1.20	98[1]
20/6/03	6	Green grey and orange Silty Clay	1	51.1	1.22	100[1]
20/6/03	7	Green grey and orange Silty Clay	0.8	42.1	1.32	89
20/6/03	8	Brown grey and orange Silty Clay	0.9	80.2	0.85	121[2]
20/6/03	9	Brown grey and orange Silty Clay	1	88.5	0.79	129[2]
20/6/03	10	Green grey Silty Clay	1	38.5	1.29	79
26/4/04	11	Green, grey and black, Gravely Silty Clay	>1.1	36.8	1.27	75
26/4/04	12	Grey, Dark-Grey, yellow, Gravely Silty Clay	>1.2	46.6	1.25	93
26/4/04	13	Green Grey Gravely Silty Clay	>1.05	26.3	1.41	60
26/4/04	14	Grey, Dark Grey Silty Clay	1.05	29.6	1.51	75
26/4/04	15	Grey, Dark Grey Silty Clay	1.1	23.8	1.43	56
26/4/04	16	Silty Clay, Grey, Green, Orange	1.1	33.7	1.3	70

*Note: A specific gravity (SG) value of 2.5t/m^3 is assumed in all 'Degree of Saturation' calculations.

1. Some fibrous organics in tube samples.
2. Large clump of fibrous organics in tube samples - reduces specific gravity of sample and provides greater voids for saturation.

2.2 Observations and Assessments

2.2.1 1st of March 2002

Six test pits were hand excavated on the southeast flank of the CWD where capping trials using clayey, extremely weathered rock material from the hanging wall of the Balstrup Fault. The various materials encountered are described in Table. 1. Grey Gravely Clay and Clayey Gravel were placed on the lower batter slope (approximately 30°) above the access road (refer to Figure 1) and were found to show no significant surface erosion, having been in place for around four months. However polygonal cracking was observed on grey materials, which subsequently closed up during wet weather. A green-grey gravely silty clay had been placed on an upper 20° slope and berm, however it had not been in place long enough to make valid judgements regarding erosion potential.

The actual waste dump materials were described as forming a 'compact, tight surface' where finished waste surfaces had been trimmed prior to capping emplacement. Batter slopes of 20° to 25° were being achieved except for existing faces sloping into the pit at between 30° to 40°.

The main points of the assessment were as follows:

- The trimming and finish of waste batters prior to placing of the capping is satisfactory;
- All areas of the trial capping are significantly less than the specified 1m;
- Compaction to date appears to have been by light tracking and packing with the bucket of an excavator. This is generally insufficient to break down large material clumps from the borrow and 'bind' the material together in the capping;
- The Grey Gravely Clay material is achieving the best compaction, forming a stiff erosion resistant surface, even on a 30° batter slope;
- The Grey Clayey Gravel contains to higher proportion of gravel and coarse fragments to be suitable as a capping material;
- The Green-grey material is generally a lower plasticity silty material, poor compaction is being achieved where the material is 'wet' and it may be prone to erosion and slumping form the batter face in this state.

Based on limited laboratory testing of cap materials at this point in the investigations, the following assessment of capping was made:

- Capping materials are generally being placed within 95% of maximum dry density and optimum moisture content.
- The degree of saturation being achieved varies from 78 to 85%. The grey gravely clay material is the only sample to meet the 85% degree of saturation stipulated in the capping design.
- The grey gravely clay (and similar) materials are preferred for capping due to the high plasticity, natural moisture close to optimum moisture content, and observed relative resistance to erosion when compacted in the cap.

The key factors in achieving the specified clay capping include:

- Careful selection of materials from the borrow area;
- Thorough compaction of the capping;
- Monitor the final capping thickness to achieve the required 1m.

The preferred borrow material is a stiff plastic clay with no more than 25% fine to medium gravel. Excessively wet, non plastic or gravely materials should be rejected.

Placement and compaction of the capping should be conducted in at least 3 layers of about 350 to 400mm loose thickness. Each layer should be fully track rolled and the surface roughened before placement of the next layer. If placement/compaction with the back of an excavator bucket is required on locally steeper (30^o) batter slopes the layer thickness should be about 200mm (5 layers required to achieve 1m cap).

'Top soiling' should be conducted onto a roughened capping surface. Some sort of geofabric mesh or net will be required to hold top soil and vegetation on slopes greater than about 25^o.

2.2.2 25th of February 2003

The area subject to capping trials on the 1st of March 2002 was revisited on the 20th of February 2003 in order to assess the emplacement technique and assist in developing a methodology for emplacement resulting in a finished cap as per Coffey's prior recommendations and DPIWE requirements.

Of the three test pits, TP03/1 & TP03/2 were located on the steeper lower slope (Refer to Figure.1) of the CWD and indicated a capping thickness in excess of 1m of well-compacted, 'massive' Grey Gravely and Silty Clay. The surface exhibited minimal cap material layering parallel to slope, some polygonal cracking, however virtually no sign of surface erosion.

Material on the upper slope to the crest of the dump (TP03/3) was found to be poorly compacted with relatively high moisture content to greater than 1m depth. Significant fibrous organic matter content was noted and the poor compaction related to the high silt and moisture content of the capping material (Brown Grey Sandy Silt with coarse root organics).

Samples from TP03/1 and 03/2 were considered to be reasonably well compacted, while the sample from TP03/3 was visually wet of optimum, poorly compacted and contained coarse, fibrous organic material from the base of the peat sward.

Previous test results from BFP indicate a range of values for recompacted clay materials from the borrow areas as follows.

Clay 'Type'	Coeff of Permeability (m/sec)	Max Dry Density (t/m3)	Optimum Moisture Content (%)
Grey Silty Clay	10^{-9}	1.34 to 1.45	29.6 to 35
Brown Grey Silty Clayey Sand	10^{-8} to 10^{-9}	1.42 to 1.65	21.2 to 30.2

Based on the field observations and subsequent laboratory testing of samples, the following assessment was made:

- The Grey Silty Clay capping materials are generally being placed within 95% of maximum dry density and optimum moisture content.
- The Brown Grey Sandy Silt, with organics is not suitable for placement as a capping material due to the very high moisture content and difficulty in working these materials once the *in situ* structure is disturbed.
- The degree of saturation being achieved for the Grey Silty Clay varies from 75 to 77%, measured approximately 5 months after placement. A sample of similar material tested soon after placement in March 2002 met the 85% degree of saturation stipulated in the capping design.

The grey gravely clay (and similar) materials are preferred for capping due to the high plasticity, natural moisture close to optimum moisture content, and observed relative resistance to erosion when compacted in the cap. Selection of suitable material at the borrow pit is essential to construction of an effective clay cap. Achievement of slightly higher compaction by track rolling in at least 3 layers should provide the required 85% degree of saturation at the time of placement. This is achievable on the 20^{o} dump slopes remaining for capping, provided care is taken in the placement methodology.

2.2.3 20th of June 2003

The flanks of the waste dump have been capped and test pits were excavated by a 20t excavator reaching down from the crest of the dump slopes. TP1 to TP5 are on the western or outer side of the dump, while TP6 to TP10 are located on the eastern side, effectively on the upper face of pit ramp.

Thin wall tube samples were taken from 10 test pit sites on the clay capping, shown approximately in Figure 1 and listed in Table.

All test pits contained lumps (from 0.1 to 0.3m across) of brown grey clay/silt with >30% coarse fibrous organics (button grass roots) scattered throughout, and estimated at between 3 and 10% of the total volume. The lumps were not concentrated in any particular horizon and generally not in contact with each other.

The silty clay materials won and placed in autumn and winter of 2003 have moisture contents significantly greater than the plastic limit, with free water present on some silt and organic materials. The moisture condition is considered to be influenced by location in the borrow pit and seasonal variations in moisture.

Samples taken from TP1, TP2, TP6, TP7 and TP10 are considered marginal in terms of meeting a laboratory permeability of 10^{-8} m/s and degree of saturation at placement of >85%. The thickness of the capping layer is considered acceptable in terms of the specification, for all test pits except TP7 and TP8 on the eastern/pit side of the dump.

Large proportions of organic matter contained within the capping material are believed to be responsible for elevated degree of saturation values e.g. 120%. Greater levels of compaction than are currently being achieved is not considered possible at this stage due to the high moisture content and characteristics of the capping materials.

The variability of materials in the borrow area is understood to be difficult to control as a result of the geology. Coffey recommend that additional effort be made where possible in the borrow areas to win material from the soil rock transition, where moisture content should less, and *in situ* density should be greater.

In general, the materials placed on the flanks of the central waste dump prior to July 2003 are of marginal suitability for the capping specification being followed. It is advised that further work may be required to assess the potential acid generation and long term characteristics of the dump if future investigations indicate the capping is not to standard.

Observations of the dump surface prior to placement of the capping materials indicate a surface of 'compact' shale material with a potentially low permeability and a final shape that is efficient at shedding surface water. The performance of the underlying dump along with infiltration modelling (e.g. SOILCOVER) of the capping profile as placed may illustrate acceptable overall dump performance with the lower part of the capping material remaining saturated year round.

2.2.4 26th of April 2004

The placement of the nominal 1m thick low permeability layer of the CWD capping has been completed, including replacement of some unsuitable materials and increasing the thickness in areas noted during the site visits of 25 February and 20 June 2003. The dump is well shaped and finished to allow placement of topsoil and effective shedding of surface runoff. Work required to complete the dump is understood to include spreading of topsoil and organic matter over the surface and construction of a shotcrete drain at the southern end of the dump where stormwater flows are causing erosion of the capping and waste materials.

The silty clay materials won and placed in spring and summer of 2003 (TP13 to TP16) have moisture contents about at the plastic limit after approximately 6 months in place on the waste dump. These materials would have been considerably wetter at the time of placement consistent with similar materials noted during site visits in 2002 and 2003.

The materials placed on the western berm in March and April 2004 (TP11 and TP12) have moisture contents greater than the plastic limit. The moisture condition is considered to be influenced by location in the borrow pit and seasonal variations in moisture and weather conditions during placement.

Based on the testing conducted and comparison to the earlier laboratory results it is inferred that all samples have an as placed degree of saturation between 75 and 95%. The range of dry density and trend for increasing dry density and decreasing moisture content over the initial period after placement suggest that equivalent lab permeability's of 10^{-8} to 10^{-9} m/s are being achieved for the samples.

The placement of capping greater than 1m thick and the observation in pits of massive to coarse (.200mm) layering of the material suggests that the capping is forming a broad barrier without obvious points of weakness vertically across the cap. The shaping of the dump surface prior to placement of topsoil materials was noted to be efficient at shedding surface water rapidly during heavy rain storms. Significant surface ponding was not noted.

In summary the materials placed on the western berm and crest of the central waste dump between August 2003 and April 2004 are of marginal suitability for the capping specification being followed, as some samples fail the degree of saturation criteria and others have a relatively low dry density indicating a potential lab permeability less than the specified 10^{-8} m/s.

3. DISCUSSION

The low permeability cap on the CWD has been constructed over a period of approximately 2 years. The key factors of the constructed capping based on the geotechnical assessments carried out include:

- The core dump is comprised of predominantly shale waste which has been well compacted in the surface layers. Laboratory testing indicates a permeability of 8 x 10^{-8} m/s for compacted shale waste;
- Shaping of the dump surface into batter slopes and berms has produced a feature that rapidly sheds stormwater with no significant ponding, which is important for potential infiltration in the west coast climate;
- Early trials and ongoing improvement of the placing process has lead to a cap greater than 1m thick, with materials placed and tamped or compacted by track rolling in 200 to 350mm thick layers.
- The borrow materials are variable in composition and moisture content leading to variable compaction and degree of saturation at placement. Experience over the 2 years of construction has shown that the materials tend to a moisture content approximately at or above the plastic limit and a range of densities consistent with an equivalent of approximately 90 to 100% of standard compaction.
- Based on the total of 20 samples tested our assessment is that the mean of the permeability and degree of saturation of the capping is approximately on design, i.e. degree of saturation 85% and permeability 10^{-8} m/s or lower. The variability indicted is relatively high, in the order of about 10 to 20% for 1 standard deviation.
- Observation in the test pits indicates that some of the variability occurs as lenses and individual lumps of 'poorer' material within layers of generally 'good' material. The observed cross section profile suggests that the capping is forming a broad barrier without obvious points of weakness vertically across the cap.

The placement of topsoil and organic matter and concreting of critical eroding drain structures will further enhance the water shedding ability and resistance to infiltration of the dump capping.

Based on the limited specification that the dump cap construction has been based on it is difficult to assess weather the overall dump shaping and capping will perform in an acceptable manner as there are no performance based parameters to judge it by. We consider that the overall low permeability cap is marginal in terms of meeting the specifications for degree of saturation and permeability at placement. However this does not preclude it from being considered fit for purpose in terms of an adequate degree of environmental protection in the historical context of the site.

In order to further demonstrate the potential performance of the capped dump it would be necessary to conduct further testing and analysis as outlined in Section 2.4 above.

For and on behalf of

COFFEY GEOSCIENCES PTY LTD

Coffey

APPENDIX A

Laboratory Test Results