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RCB

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Geotechnical Advice on Durability of In situ Rock
Proposed Industrial Subdivision
290-308 Aldington Rd, 59-63 Abbotts Rd & 1030-1064 Mamre Rd, Kemps Creek

1. Introduction

This report presents the results of a geotechnical review undertaken by Douglas Partners Pty Ltd (DP) of the likely suitability of excavated rock sourced from the above site for beneficial reuse within reinforced backfill zones in proposed reinforced earth retaining walls (RE walls) to be constructed across the development. The review was requested by ESR Australia Pty Ltd (ESR).

It is understood that a number of relatively medium to large RE walls are proposed along property and internal lot boundaries with the locations, heights and lengths of the walls currently being finalised. As the site will undergo significant excavations to depths of 20 m or more, a considerable volume of rock will be removed. The ripped rock will be reused as controlled fill on the site and the question has arisen as to whether the rock would also be a suitable source of reinforced backfill for reinforced earth walls.

2. Background

DP has completed previous investigations across the industrial development site. The results of the investigations were presented in the following reports:

- Geotechnical Report – 59-63 Abbotts Rd (92352.00.R.002.Rev0, dated 19/8/19, DP 2019).
- Geotechnical Report – 1030-1048 Mamre Rd (211619.00.R.001.Rev0 dated 30/3/22, DP 2021).
- Geotechnical Report – 1050-1064 Mamre Rd (207450.00.R.001.Rev0 dated 20/12/21, DP 2022a).
- Geotechnical Report – 290-308 Aldington Rd, 59-63 Abbotts Rd & 1030-1064 Mamre Rd (92352.03.R.001.Rev0 dated 7/9/22, DP 2022b).

The various reports provide details on site and subsurface conditions, soil and rock classification and strength, excavation and excavatability, earthworks, retaining walls, vibration, footings and pavements. The reports were based on the findings of several staged investigations that included the drilling of boreholes, the excavation of test pits and laboratory testing of selected samples.

The results presented in the previous reports have been used to provide the additional information outlined herein.

3. Retaining Wall Types

It is understood that reinforced earth walls with masonry block facing units are proposed. Wall heights will vary up to 10 m (possibly higher) subject to intermittent wall terracing and the integration of landscaped batters in the overall design of grade separations between adjoining lots/sites.

4. Retaining Wall Requirements

The specification requirements for the proposed RE walls were provided by ESR and have been taken from a current RE wall specification prepared by Retaining Solutions Pty Ltd. A copy of the specification excerpt is attached. In summary, the specification requires the reinforced backfill to comply with:

- Maximum particle size: 75 mm or not greater than one third of the maximum layer thickness.
- Particle size distribution:
  - % Passing 9.5 mm sieve: 25 – 100
  - % Passing 2.36 mm sieve: 15 – 100
  - % Passing 600 µm sieve: 10 – 100
  - % Passing 75 µm sieve: 0 – 15
- Coefficient of uniformity: greater than 5%
- Atterberg limits:
  - Liquid limit: less than 30%
  - Plasticity index: less than 12%
- pH:
  - PET polyester geogrid: 4 – 9
  - HDPE high density polyethylene geogrid: 2 – 12.5
- Effective peak friction angle: 34 – 36 degrees
- Material Type: Nothing derived from argillaceous rock (e.g. shale, claystone or other friable materials susceptible to breakdown)

In addition, the Australian Standard AS2758.4-2017 Aggregates and rock for engineering purposes (aggregate for gabion baskets and wire mattresses) provides requirements for rock durability that should also be considered when assessing the suitability of a ripped rock source for use as a reinforced backfill. The durability requirements of the Standard directly relate to the final bullet point above, and indirectly to the method of compliance testing for all other bullet points.

5. Site Won Materials

Based on the results of the investigation it is apparent that the following materials will be won from excavations on the site:

- Soil – including natural and filled topsoil, gravelly and clayey fill and natural clay, silty clay, gravelly clay and sandy clay.
- Rock – including highly weathered to fresh interbedded and interlaminated siltstone and sandstone units, siltstone units and sandstone units of typically very low strength to medium strength but with high strength bands and variable weathering.

6. Comments

6.1 Preferred Materials

It is known from previous projects that reinforced backfill materials typically comprise highly granular ripped or crushed rock, usually sourced from a sandstone rock formation. Other rock types may, on occasion, comply with a project's specification (e.g. granite, basalt, and high strength slightly weathered to fresh siltstone), although soils and rock of medium strength (or lower) do not satisfy the minimum specification requirements. When ripped or crushed, these 'other' materials almost always produce too high a content of fines that are often too plastic or are of insufficient durability. Further, there have been cases where high strength ripped siltstone has been used in RE Walls but it has later been shown that some of those walls have undergone adverse settlement and suffered geogrid slippage following reinforced backfill breakdown.

The preferred material type for reinforced backfill for RE wall projects undertaken in Sydney therefore includes ripped or crushed sandstone that is slightly weathered to fresh and of at least high strength.

6.2 Site Won Material Types

It is known that the site is underlain by the Bringelly Shale formation of the Wianamatta Group. The Bringelly Shale formation typically comprises shale, carbonaceous claystone, laminite, fine to medium grained lithic sandstone with some coal bands and tuff.

From the results of DP's previous investigations, the rock on the site mostly comprises siltstone, or siltstone that is interbedded/interlaminated with sandstone almost always as the minor component. A smaller component of the rock comprises sandstone and Table 1 provides a summary of the zones of potentially suitable sandstone (i.e. that is slightly weathered to fresh and of at least high strength) that were encountered above the proposed bulk excavation levels (BEL) in recent boreholes drilled at the site [refer DP2022b] .

Table 1: Zones of Slightly Weathered High Strength Sandstone

Borehole	BEL at Borehole (RL, m AHD)	Sandstone	High Strength (or better)	Slightly Weathered (or better)
		Reduced Level Range above Bulk Excavation Level (m AHD)		
BH1	64.7	Nil	Nil	Nil
BH2	71.7	82.1 – 78.8	82.1 – 79.7	82.1 – 79.7
BH3	71.7	Nil	Nil	Nil
BH4	74.7	Nil	Nil	Nil
BH5	74.7	80.4 – 75.9	80.4 – 79.4 78.6 – 76.6	Nil
BH6	74.7	Nil	Nil	Nil

From Table 1 it can be seen that sandstone was only encountered in two of the six boreholes and in limited thicknesses. Further, sandstone with a suitable degree of weathering and strength was only encountered in BH2 over a relatively limited thickness of 2.4 m. Accordingly, Table 1 indicates that a consistent source of suitable sandstone is not available within the proposed depth of excavation and that sandstone of any quality is only intermittently present across the site.

6.3 RE Wall Specification Compliance

Most of the requirements listed in the supplied specification excerpt relate to physical properties, including maximum particle size, particle size distribution and coefficient of uniformity. These requirements can be achieved through appropriate material ripping and processing irrespective of rock type and therefore they relate to material suitability in terms of construction, rather than suitability in terms of source rock. That said, it is likely that a considerably higher content of fines (i.e. % passing the 75 µm sieve) will be derived during the rock excavation process, which would require a second round of processing to remove the fines before use.

The specification requirements for plasticity, pH and effective friction angle are directly related to the characteristics of the rock and to a lesser degree material processing. Experience with ripped rock derived from the Bringelly Shale formation, including extensive testing undertaken as part of the M7 Motorway construction, indicates that the specified limits are unlikely to be achieved. Plasticity index values are likely to be routinely above 12% (i.e. up to 20%) and effective friction angles routinely below 34 degrees (i.e. 28 to 33 degrees). Higher than desirable backfill plasticity reduces the friction along the soil/geogrid contact and increases the risk of geogrid slippage. Lower effective friction angles require substantial increases in wall geometry (i.e. increased geogrid lengths) increasing the required volume of reinforced backfill and the overall cost of wall construction.

The final specification requirement simply states that no argillaceous rock is to be used. The term argillaceous is defined as ‘consisting of or containing clay’. This precludes the use of all rock types that

are derived of clay fines or contain an adverse content of clay. This essentially negates the use of all rock types likely to be encountered within the proposed excavation. Although the sandstone encountered in BH2 is potentially suitable in terms of its degree of weathering and strength classification, the mineralogy of the rock is likely to of an argillaceous nature given the surrounding rock formation.

6.4 Durability

Durability can be described as being able to exist for a long time without significant deterioration in quality or condition. In terms of reinforced backfill, suitable ripped rock must be derived from dense, hard, durable and clean rock that is resistant to the weathering actions of air and water and free from cracks or other structural defects that may reduce its mechanical strength and resistance to weathering. This means that the condition of the ripped rock when placed must be maintained throughout the life of the RE wall and that no material breakdown can occur that would render the material incapable of satisfying the specified requirements.

Experience with ripped rock derived from Bringelly Shale indicates that even high strength sandstone is unlikely to demonstrate satisfactory durability when subjected to testing. AS2758.4 provided for two methods of assessing rock durability, including Los Angeles abrasion and unsound and marginal stone content tests, and wet strength and wet/dry strength variation tests. We comment on each:

- Los Angeles abrasion and unsound and marginal stone – this testing procedure would require a specific sample of at least 100 kg mass to be representatively reduced to a suitable test portion. The sample would then need to undergo pre-treatment by repeated compaction and artificial weathering before being subjected to the durability tests. The Standard then requires a maximum abrasion loss of 25%, a maximum unsound stone content of 5% and a maximum unsound and marginal stone content of 10%. Experience suggests that these values are unlikely to be routinely achieved.
- Wet strength and wet/dry strength variation – this testing procedure would require a similar and specific sample to be representatively reduced to a suitable test portion. The sample would then need to undergo pre-treatment by repeated compaction and artificial weathering before being subjected to the durability test. The Standard then requires a minimum wet strength of 100 kN and a maximum wet/dry strength variation of 35%. Experience suggests that the wet/dry strength variation is likely to be significantly greater than 35%.

6.5 Conclusion

As outlined above it is apparent that there is only a limited quantity of potentially suitable sandstone on the site and within the depth of the proposed bulk excavations. Whilst there is a limited volume of potentially suitable sandstone in the vicinity of BH2 (6.8 m to 9.2 m depth) it is unlikely that this source will satisfy the project's specification requirements. To specifically assess whether this material is suitable for use as reinforced backfill, it is considered that the following would need to occur:

- Seek approval from the retaining wall designer to use this source of sandstone, subject to demonstration of satisfactory test results. We note that the use of ripped sandstone derived from

a specific sandstone bed of potentially limited extent in Bringelly Sandstone may result in changes to wall designs and associated warranties.

- Excavate a number of test pits (say 3) in the vicinity of BH2 and to the appropriate depth to confirm continuance of the source and to collect large bulk samples. If the source appears to have a sufficient volume, schedule at least two samples for laboratory testing, including:
  - Crushing of the bulk samples to a maximum 75 mm particle size
  - Riffling and preparation of the bulk samples into at least two large representative samples
  - Separation of the larger samples into representative sub-samples
  - Particle size distribution on the sub-samples prior to pre-treatment
  - Pre-treatment by repeated compaction of all sub-samples
  - Pre-treatment by artificial weathering of all sub-samples
  - Particle size distribution on the pre-treated sub-samples (to note any material breakdown)
  - Atterberg limits tests on the pre-treated sub-samples
  - pH tests on the pre-treated sub-samples
  - Shear-box tests on the pre-treated sub-samples
  - Wet strength and wet/dry strength variation tests on the pre-treated sub-samples

The above testing programme could be undertaken prior to or during construction. Subject to the urgency of the work, it is noted that the tests could be staged so that the results indicate compliance before continuing with the next test. It is suggested that the source is not approved unless at least three satisfactory sets of results are achieved.

7. Limitations

Douglas Partners (DP) has prepared this report for this project at 290-308 Aldington Rd, 59-63 Abbotts Rd & 1030-1064 Mamre Rd, Kemps Creek in accordance with instructions received from Daniel Galea of ESR Australia Pty Ltd. The work was carried out under DP's Conditions of Engagement. This report is provided for the exclusive use of ESR Australia for this project only and for the purposes as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of DP, does so entirely at its own risk and without recourse to DP for any loss or damage. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

DP's advice is based upon the conditions encountered during recent investigations (2019-2022). The accuracy of the advice provided by DP in this report may be affected by undetected variations in ground conditions across the site between and beyond the sampling and/or testing locations. The advice may also be limited by budget constraints imposed by others or by site accessibility.

The assessment of atypical safety hazards arising from this advice is restricted to the geotechnical components set out in this report and based on known project conditions and stated design advice and

assumptions. While some recommendations for safe controls may be provided, detailed 'safety in design' assessment is outside the current scope of this report and requires additional project data and assessment.

This report must be read in conjunction with all of the attached and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion stated in this report.

This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by DP. This is because this report has been written as advice and opinion rather than instructions for construction.

Please contact the undersigned if you have any questions on this matter.

Yours faithfully
Douglas Partners Pty Ltd

Reviewed by

Ray Blinman
Principal

Hugh Burbidge
Principal

Attachments: About this Report
Retaining Solutions Pty Ltd Specification Excerpt

About this Report

Douglas Partners

Introduction

These notes have been provided to amplify DP's report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

DP's reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

Copyright

Borehole and Test Pit Logs

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable or possible to justify on economic grounds. In any case the boreholes and test pits represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

Where groundwater levels are measured in boreholes there are several potential problems, namely:

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole is left open;
- A localised, perched water table may lead to an erroneous indication of the true water table;
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

If these occur, DP will be pleased to assist with investigations or advice to resolve the matter.

About this Report

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes

Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

Annexure A: Reinforced Backfill Requirements (Physical/Chemical)

Physical Criteria

Requirement	AS 1289	RSW Material Parameters
Maximum size (mm) prior to prior placement and Compaction	-	50 to 75mm for geosynthetic reinforcement. For all soil reinforcement, maximum size of granular material shall not be greater than one third of max lift thickness.
% Passing 9.5mm (AS) Sieve Size	Test 6.1	25-100
% Passing 2.36mm (AS) Sieve Size	Test 6.1	15-100
% Passing 600 microns (AS) Sieve Size	Test 6.1	10-100
% Passing 75 microns (AS) Sieve Size	Test 6.1	0-15
Coefficient of Uniformity	N/A	≥ 5
Liquid Limit LL (%)	Test 3.1.1	≤ 30
Plasticity Index PI (%)	Test Part 3.2.1 and Part 3.3.1	≤ 12

Notes: (1) Test Methods shall be specified in AS 1289

(2) The Coefficient of uniformity = D_{60}/D_{10} where D_{60} and D_{10} are the equivalent sieve sizes in millimetres as interpolated from particle size distribution curve and through which 60% and 10% of the reinforced fill material passes respectively.

(3) Material shall be pre-treated:

(a) In accordance with RTA T102 using 3 repeated Compaction cycles; and then

(b) In accordance with RTA T102 by artificial weathering using 5 cycles of alternative wetting and drying. The % passing 75 microns (AS) sieve size shall not exceed 15% and the Plasticity Index PI shall not exceed 12%;

Prior to testing unless otherwise approved by the Superintendent.

(4) Material derived from argillaceous rock such as shale and claystones or other friable materials which are susceptible to breakdown shall not be used as reinforced fill material.

Chemical Criteria

pH	Test Method	Allowable Limits
pH	AS1289 4.3.1	4 – 9 (PET - Polyester geogrid) 2-12.5 (HDPE – High Density Polyethylene geogrid)

For backfill with pH values outside the tabulated allowable limits above, refer to geogrid manufacturers for specialist advice of environmental/durability long-term effects.

Annexure B: Reinforced Backfill Testing & Compaction Requirements

Material proposed to be used, as backfill should be tested in accordance with the requirements.

TESTS	FREQUENCY
pH	Not Less Than: 3 tests on the first 2,000 cu.m 1 test for each successive 2,000 cu.m up to a total volume of 10,000 cu.m 1 test for each successive 3,000 cu.m in excess of 10,000 cu.m
Design Grading envelope, PI and LL, friction angle	Not Less Than : Minimum 1 test per structure 3 tests on the first 2,000 cu.m 1 test for each successive 4,000 cu.m up to a total of 10,000 cu.m 1 test for each successive 6,000 cu.m in excess for 10,000 cu.m
Compaction	In accordance with AS1289. E5.5.1, E5.1.1.1, 5.3.1, 5.4.1, 5.8.1
Density Testing	In accordance with AS3798 – refer notes below
Internal Friction angle	In accordance with AS1289 6.2.2 – *Min effective peak friction angle 34 to 36 degrees*

Notes:

(A) The above frequency should apply only to the cumulative volume of material which is obtained from the same source of supply, i.e. the same quarry or borrow area. If the source of borrow is altered, the above frequency of testing should apply to the respective cumulative volumes of material obtained from each separate source.

(B) At all times during the placement, the site engineer should visually assess the material for uniformity. In the event that a variation in quality is detected, a suite of testing should be carried out on the material to assess compliance.

(C) The above frequencies are suggested as a guide to the minimum number of tests required to ensure compliance of general backfill materials. Prudent requirements for control will vary with the actual mean value and standard deviations of the actual test results and it is suggested that the frequency of testing for volumes greater than 2,000 cu.m be assessed on an individual basis, using the results of the initial testing.

(D) Backfill Field Density Testing frequency of testing should be greater of a least one test/500cu.m of backfill material or one test/layer/1000 sq.m plan area of backfill. For plan areas less than 1000m2, one test/200cu.m. A greater frequency of field-testing should be adopted where the Site Engineer deems it necessary.