AGS VICTORIA 2016 SYMPOSIUM

Excavations and slope stability in Melbourne geology: experiences and recent developments

Wednesday, 16 November 2016, 12:00pm – 7:00pm
Engineers Australia, 600 Bourke Street, Melbourne

AUSTRALIAN GEOMECHANICS SOCIETY
VICTORIA CHAPTER

WELCOME

The Victorian chapter of the Australian Geomechanics Society (AGS) is pleased to welcome you to this half-day symposium titled “Excavations and slope stability in Melbourne geology: experiences and recent developments”.

Since the publication of the “Engineering Geology of Melbourne” in 1992, both the geotechnical profession and Melbourne has undergone significant change. Urban sprawl over the past few decades has seen increasing development in the hillside areas in the Dandenong and Mornington Peninsula regions. This coupled with changes to the regulatory environment and the introduction of the Landslide Risk Management Framework by the AGS in 2007 has changed the way in which local and state government as well as geotechnical practioners manage and assess slope stability.

In addition to development in hillside areas, significant development in the inner parts of Melbourne has posed many challenges for excavations not just in the soft soils of the Yarra Delta but also the weak rock of the Melbourne Formation.

This symposium seeks to bring together practioners from consulting, construction and academia to share and discuss their experiences on the separate, but related, topics of excavation and slope stability. Best practices, case histories and innovative solutions for dealing with these challenges will be presented and discussed, with a particular emphasis on local geotechnical issues.

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GEOLOGY AND GEOTECHNICAL CHARACTERISTICS OF THE GEELONG CBD

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ABSTRACT

This paper supplements the published geology of the Geelong CBD with previously unpublished geotechnical borehole records. The additional data is used to adjust the published geological boundaries and provide information on the geotechnical properties of the encountered units.

Keywords: Geelong, geology, geotechnical, Gellibrand Marl, Beaumaris Sandstone, Newer Volcanics

1 INTRODUCTION

Geelong, Victoria's second largest city, lies on Corio Bay, approximately 70 kilometres south west of Melbourne. The geology of the Geelong Central Business District (CBD) is currently defined by the Geological Survey of Victoria (GSV) Seamless Geology (2007-2014) as consisting of Gellibrand Marl, overlain by Beaumaris Sandstone, overlain by Newer Volcanics with Coastal dune deposits overlying the Gellibrand Marl near the present day shore line.

Geotechnical practitioners have access to the published geology, such as Spencer-Jones (1970) and up to date maps on the GeoVic web site, but to date there has been no specific publications providing geotechnical data for the Geelong CBD, despite the ongoing infrastructure development.

This paper supplements the published geology with previously unpublished borehole records. The additional data is used to adjust the published geological boundaries and to provide information on the geotechnical properties of the encountered units. The unpublished database includes boreholes drilled at eight different sites across the Geelong CBD from 2007 to 2015 (Figure 1). All were drilled by the same geotechnical consultancy for various development projects with borehole logging by a number of different employees.

Figure 1. Site and Section Locations

2 GEOLOGICAL NOMENCLATURE

The naming of geological units is an ongoing process overseen by Geoscience Australia, with unit names and groupings regularly redefined as new data comes to light and Geoscience Australia becomes aware of name clashes with geological units elsewhere in Australia. This process has led to the Moorabool Viaduct Sand being renamed the Beaumaris Sandstone (after being named the Black Rock Sandstone in the interim, but the name having to be discontinued due to it already being in use elsewhere) and the Fyansford Formation being renamed the Gellibrand Marl. The Newer Volcanics is unchanged. For the purposes of this paper, we have adopted the present geological names as defined by Geoscience Australia on the online Australian Stratigraphic Units database.

3 GEOLOGICAL UNITS

3.1 Gellibrand Marl

The Gellibrand Marl is the oldest (between about 10Ma and 20Ma) geotechnical unit exposed in the Geelong CBD, having surficial expression in the north eastern part of the CBD near Eastern Beach Road (Figure 2). Deeper boreholes intersected the Gellibrand Marl in places underlying the younger Beaumaris Sandstone and we consider that the Gellibrand Marl is likely to occur consistently at depth across the Geelong CBD. Geoscience Australia's stratigraphic units database notes that the Gellibrand Marl are marine shelf deposits, comprising clay, marl and worm-burrowed calcarenite, fine to medium grained quartz and detrital calcareous fossil fragments in clay matrix, moderately sorted, massive to well bedded. In addition our boreholes encountered high plasticity silty clay, clayey silt, sand and clayey sand, cemented sand lenses and shells. The clay ranged from stiff to hard and returned Standard Penetration Test (SPT) N values ranging from 7 to >50 in clay. The sand was Medium Dense to Very Dense with SPT N values ranging from 26 to >50. Haberfield (1992) discussed the geotechnical properties of the Fyansford Formation (as the Gellibrand Marl was then known) in the Geelong suburb of Belmont, centred about 3 kilometres south of the Geelong CBD. The geotechnical properties noted by Haberfield (1992) were similar to those we noted above, with the exception that Haberfield (1992) reported 0 to 1m thick layers of extremely weathered to moderately weathered limestone within the sand layers. Point Load Index results from testing of the limestone were mostly between 0.2MPa and 2.5MPa, with a highest result of 6.3MPa.

3.2 Beaumaris Sandstone

The Beaumaris Sandstone is the second oldest unit (about 5 Ma) exposed in the Geelong CBD. It overlies the Gellibrand Marl and typically underlies the Newer Volcanics. The Australian stratigraphic units database notes that it is an extensively bioturbated sequence of marine sands and silts which includes a basal phosphatic nodule layer including an assemblage of vertebrate teeth and bones. The lower horizons are calcareous with higher horizons non-calcareous and ferruginous.

Our borehole database noted that it comprised high plasticity and low plasticity clay, low liquid limit silt, ranging from Firm to Hard, with SPT N values from 5 to >50. It also comprises Medium Dense to Very Dense fine to coarse grained sand with SPT N values ranging from 17 to greater than 50. Thin calcareous sandstone layers of about 200mm width were occasionally encountered.

In places the Beaumaris Sandstone was absent or not identified between the Gellibrand Marl and the Newer Volcanics, with one such example displayed in Section B-B (Figure 3).

3.3 Newer Volcanics

The Newer Volcanics consists of Quaternary age basalt flows (about 2 Ma) that originated from volcanoes to the north west of the current CBD. Based on our assessment of Boyce (2012) we consider that the most likely source for the Newer Volcanics in the Geelong CBD is Mount Anakie, located about twenty five kilometres to the north northwest. Based on the distribution and thickness of the basalt, we consider that the CBD area is approaching the limit of the flow extent. The Newer Volcanics is deeply weathered in the CBD area and is often encountered as residual or extremely weathered soil, with rock often absent. The residual or extremely weathered clay is high plasticity, ranging from firm to hard with SPT values from N = 4 to >50. There are also lenses of Dense to Very Dense clayey sand, and gravelly sand within the sequence with SPT values typically of N>50.

A maximum vertical thickness of 8m has been encountered in the boreholes considered for this paper. The thickest intersection of basalt rock is approximately 5m. The observed basalt was vesicular, fractured and of high strength.

A borehole from our database drilled near the intersection of Corio Street and Malop Street failed to intersect Newer Volcanics, suggesting that in this area the boundary between the surface expression of the Beaumaris Sandstone and the Newer Volcanics is about 100m further south than is currently mapped by the GSV. Our revised boundary is shown below (Figure 2).

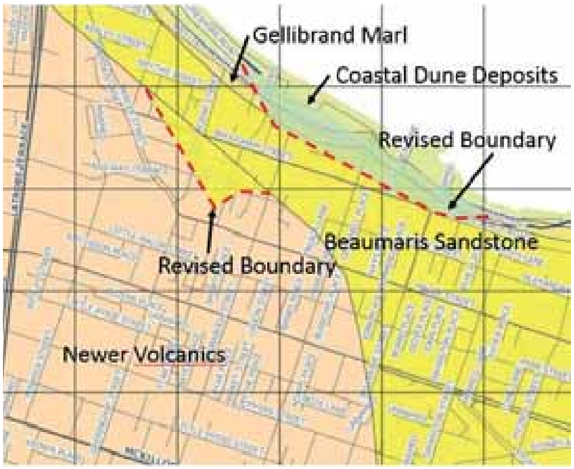

Figure 2. GSV seamless geology with revised boundaries

3.4 Coastal Dunes Deposits

Quaternary age coastal sand dunes (probably Holocene epoch, <11000 BP) are mapped by the Geological Survey of Victoria as occurring on the Geelong foreshore, where they unconformably overly the Gellibrand Marl. The coastal sand dunes are notably younger than the Newer Volcanics and thus must have been deposited on the margin of the Newer Volcanics an example of which is presented in Section B-B' (Figure 3). The GSV notes that this unit comprises sand, silt and clay and that it is well sorted and poorly consolidated. They concluded it is derived from coastal dune and beach deposits with some swamp deposits.

A group of boreholes from our database were drilled near Cunningham Street, close to Western Beach Road and encountered low to high plasticity, Very Soft to Stiff clay (SPT N= 0 to 9) and fine to coarse grained Loose to Very Loose sand that returned SPT values of N = 0 to 3 and similar material was encountered near the intersections of Brougham and Bellerine Streets.

The borehole data indicates that the area tested was a low energy environment, such as swamp deposits, which were dissected by fluvial channels, leaving the sand lenses. The higher strength clay was encountered near the top of the unit and we consider it likely that the increased strength is due to surficial desiccation and evaporation. Our revised geological boundary is shown on Figure 2.

4 EXCAVATABILITY

The Gellibrand Marl and Beaumaris Sandstone are readily excavatable by conventional methods. The Beaumaris Sandstone includes layers of clean sand. Where these are encountered beneath the water table, excavation is likely to require de-watering or non-conventional methods to proceed. The coastal dune deposits and associated units are of low strength and will be readily excavatable where they exist above groundwater. As with the Beaumaris Sandstone, the sand lenses below the water table will require de-watering or non-conventional methods for excavation.

The Gellibrand Marl is known to have layers of weathered limestone in Belmont, to the south of the Geelong CBD. Although these limestone layers were noted in our database, if they occur in isolated parts of the CBD they may require the use of a rock breaker to assist excavation.

The Newer Volcanics is predominately soil strength and thus could predominately be excavated by conventional methods. In the few locations that boreholes intersected basalt rock, it was highly fractured, indicating that excavation would be relatively straight forward with conventional equipment and that heavy use of rock breakers is unlikely to be required when these conditions exist.

5 SLOPE STABILITY

The Gellibrand Marl, Beaumaris Sandstone and Newer Volcanics units encountered are soil strength and are, in general, when dry, likely to be at risk of becoming unstable at angles steeper than 45^0. Permanent batters are expected to require flatter angles. Steeper temporary batters may be possible on a case by case basis where one of the following was present:

- Limestone horizons (Gellibrand Marl);
- Cemented sand horizons (Beaumaris Sandstone); and
- Basalt rock (Newer Volcanics)

The coastal dune deposits are of low strength and will require flatter angles than stated above. Given the low strength nature of these materials the coastal dune deposits will require assessment of stable batter angles on a case by case basis.

Where groundwater is present batters may also require flatter angles and this should also be assessed on a case by case basis.

6 DISTRIBUTION OF UNITS

Cross sections A-A' and B-B' (Figure 3) are attached. These show the inferred geotechnical profile east-west and north-south respectively.

7 CONCLUSION

We have provided new geotechnical information on the units that occurred in the Geelong CBD, including a minor revision to the surficial geology and cross sections providing an indication of the likely sub surface profile. The information will be of use in assessing geotechnical conditions in the Geelong CBD and should be a starting point of further revisions as more data becomes available.

8 ACKNOWLEDGEMENTS

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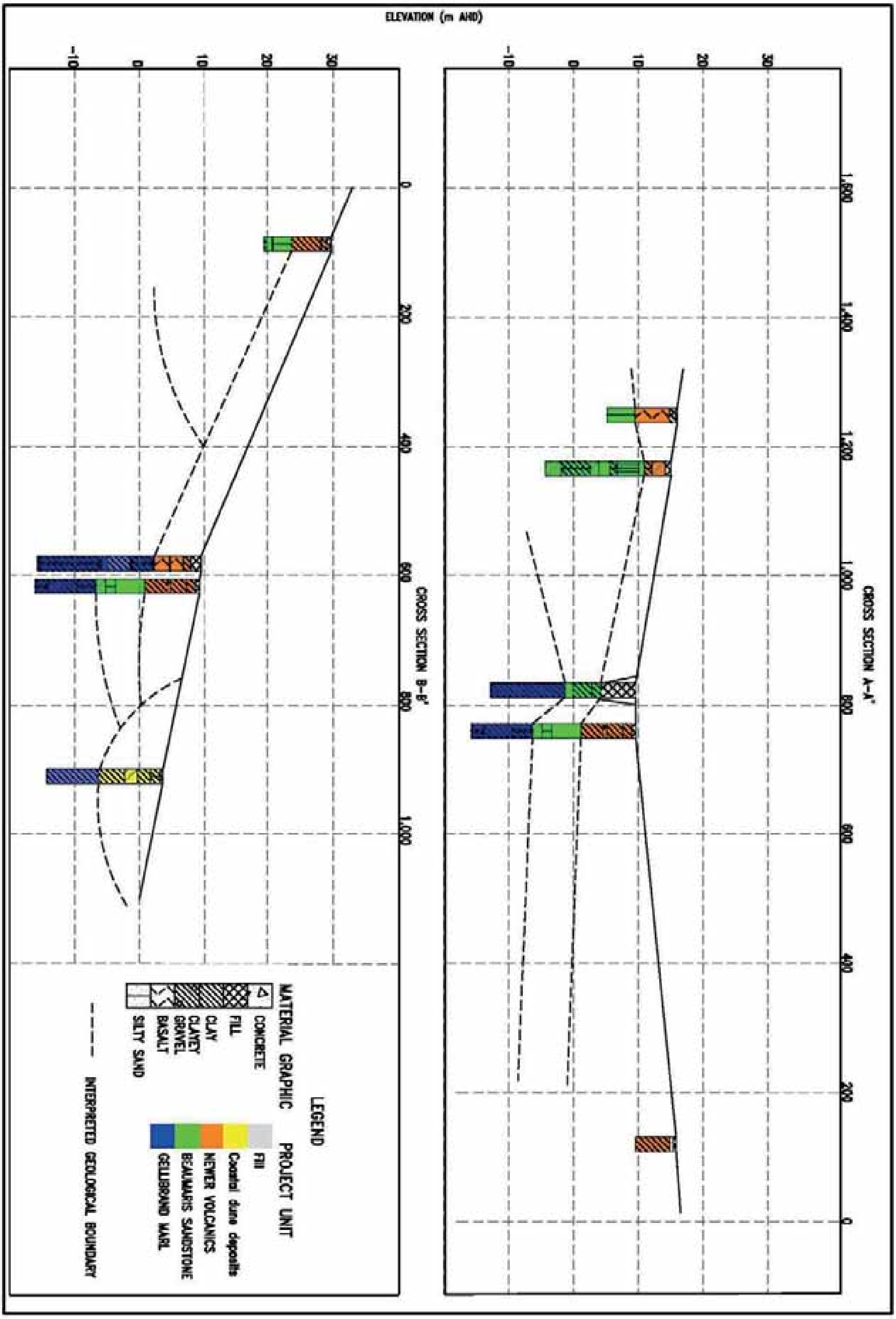
ELEVATION (m AHD)
CROSS SECTION A-A'
CROSS SECTION B-B'
LEGEND
MATERIAL GRAPHIC
CONCRETE
FILL
CLAY
CLAYEY GRAVEL
BASALT
SILTY SAND
PROJECT UNIT
Fill
Coastal dune deposits
NEWER VOLCANICS
BEAUMARIS SANDSTONE
GELLIBRAND MARL
INTERPRETED GEOLOGICAL BOUNDARY

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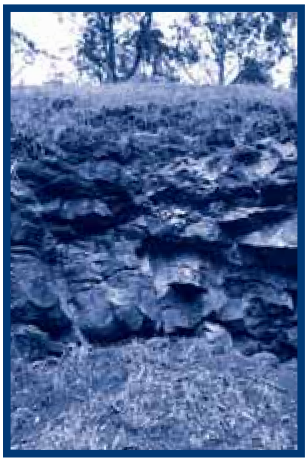

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