SOTO Consulting Engineers
113 Princes Highway
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ABN 58113350146

Document Reference No. 14235-RPT-001 Addendum
SOTO Project No. 2014-00235

Date: 04 November 2014

To: Fulton Hogan

Attn: Mr David Bender

Re: **Structural Engineering Report - Foxground Berry Bypass**
Structural Vibration Assessment of Dry Stone Wall (G2B H54)
455 Princes Highway Broughton Village, NSW

Dear Sir

1. INTRODUCTION

Fulton Hogan has been awarded the contract for the design and construction of the Foxground and Berry Bypass, Stage 2 of the Princes Highway upgrade located approximately 150 kilometres south of Sydney. As part of the proposed road work, Fulton Hogan intends to undertake road excavation utilising blasting techniques in the vicinity of an existing 230 m long (approx.) dry stone wall adjoining the property at 455 Princes Highway Broughton Village, NSW. The dry stone wall is a non-Aboriginal heritage item of local significance. SOTO understands the nearest distance of the proposed blasting to the wall is 18m.

Fulton Hogan commissioned SOTO to undertake a structural investigation and prepare a report in relation to the effects of the proposed blasting on the wall. The purpose of this investigation was to undertake an assessment of the effects of blasting and provide recommendations in relation to acceptable ground vibration limits for the wall. Detailed advanced analysis, vibration and response monitoring were not undertaken as part of this study.

To assist with the investigation, SOTO confirms receipt of the following documentation:

- Fulton Hogan – Foxground and Berry Bypass – Appendix D – Blast Management Plan, dated 03/09/2014.
- Fulton Hogan – Foxground and Berry Bypass – Vegetations to be Cleared – Map – Sheet 2 (Information Document: FBB-K-CLEARING_MAP_02).
- G2B H54. Princes Highway upgrade - Foxground and Berry bypass Appendix K – Appendix G – 159 Roads and Maritime Services Non-Aboriginal (historic) assessment.
- Peter Bellairs Consulting Pty Ltd – Foxground to Berry Bypass Cut 2 Ground Vibration Recommendations for Dry Stone Wall and Residence Blasting Risk Mitigation Strategies Report Dated 22 May 2014.
- Project Approval granted on 22 July 2013.

SOTO understands that the wall may have been a component of the 1870s highway alignment. The wall is not relied upon to define or enforce a property boundary or otherwise.

2. OBSERVATIONS

SOTO Structural Engineer's Mr Rick Minato and Mr Jose Luis Caballero attended the site on 8 October 2014 to inspect the wall and review the general configuration and condition of the structure. The inspection included only the visually accessible components of the wall. A brief photographic overview is provided below. A complete photographic survey is provided in Appendix A.

Photograph 2.1 - View from North.

Photograph 2.2 - View from South.

The general observations at the time of inspection were consistent with the summary outlined in the supplied document: G2B H54. Princes Highway upgrade - Foxground and Berry bypass Appendix K – Appendix G – 159 Roads and Maritime Services Non-Aboriginal (historic) assessment. Access to the wall was limited by dense overgrowth and the wall was accessible and visible in only a small number of places. The overall length and condition of the wall was not confirmed at the time of inspection. Based on observations in the exposed areas, the base of the wall is approximately 1.0 metres to 1.2 metres wide and the height roughly 1.1 metre. The wall appeared to have been constructed using the 'double dyke' technique which is characteristic of the Kiama and Foxground walls. The wall was partially retaining soil with a higher ground level on the upslope side. Areas of partial collapse and missing copestones were noted.

3. BLASTING CRITERIA

Subsequent to inspection, SOTO completed a structural review of the wall based on a desktop study of the supplied documentation, relevant published reports and Australian and International Standards. Referring to Table 2 of the Project Approval; the project vibration limit for blasting at the Dry Stone Wall is Peak Particle Velocity (PPV) = 3 mm/s at a nearest distance of 18m.

The relevant Australian Standards do not provide specific vibration limit guidance for dry stone walls or similar structures. However, AS 2187.2-2006 (Appendix J) provides guidance for the assessment of structural damage to 'buildings' caused by vibration. This part of the standard is based on the British Standard 7385: Part 2 "Evaluation and measurement of vibration in buildings" and is used as a guide to assess the likelihood of building damage on commercial or residential properties from ground borne vibration. The German Standard DIN 4150-3 identifies more stringent frequency dependant vibration levels for building damage and includes a category specifically for 'sensitive structures' (extract reproduced in Table 3.1 below). It appears the project vibration limit for blasting at the Dry Stone Wall (PPV = 3 mm/s) has been classified based on the guidelines of DIN 4150-3 for 'sensitive structures' of 'great' intrinsic value. SOTO considers this classification not applicable for the dry stone wall. As discussed below, SOTO does not consider the dry stone wall to be a 'sensitive structure' and such an overly conservative classification is not consistent with the intent of the Standard.

Table 3.1 - German DIN Standard 4150-3

Line	Type of Structures	Peak particle velocity PPV (mm/s) at foundation		
		< 10 Hz	10-50 Hz	50-100 Hz
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design.	20	20-40	40-50
2	Dwellings and buildings of similar design and/or occupancy.	5	5-15	15-20
3	Structures that, because of their particular sensitivity to vibration, cannot be classified under lines 1 and 2 and are of great intrinsic value (e.g. listed buildings under preservation order).	3	3-8	8-10

The Blast Mitigation Report prepared by Peter Bellairs Consulting Pty Ltd, dated 22 May 2014 indicates that blast induced vibration frequencies in the vicinity of the dry stone wall are expected to be in the order of 100 Hz.

4. STRUCTURAL ASSESSMENT

The dry stone wall structure consists of piles of random (non-coursed) hand placed boulders, cobbles and gravel. The potential mechanisms for such a wall to be disturbed by blasting are considered to be:

- Permanent surface displacement along jointing planes.
- Toppling or displacement of rocks from the wall.
- Impact of flyrock of sufficient size.

The response of the wall to any ground induced vibration is a function of the natural frequency of the structure. The vibration levels at which rocks could move or topple is a function of their shape, inertia, mechanical interlocking, friction and gravity. In addition to any potential effects of blasting, the wall has been and will continue to be subjected to environmental actions such as subgrade movement, earth pressure, earthquake, wind, torrential rain, tree growth, wildlife, vehicle movement, and human influence; all of which may cause rocks to topple or dislodge. The current state of wall dilapidation is the likely result of such environmental factors.

Based on the information outlined above, SOTO considers the project vibration limit of PPV = 3 mm/s for the dry stone wall to be excessively conservative for the following reasons:

- The wall does not fit into the nominated categories (commercial/industrial, domestic or heritage buildings) as per the relevant Australian, British and German Standard guidelines.
- The specified limit is not consistent with the intent of the Standards for this type of structure.
- The wall is not an occupied structure.
- Blasting activities are expected to generate vibration frequencies in the order of 100 Hz due to the proximity of the wall. In this case, the blast induced vibration frequency would not cause resonance and damage the wall.
- Distress from blasting activities is unlikely to exceed the effects, environmental actions and traffic vibrations to which the wall is continually subjected.

The wall construction is not brittle and SOTO does not consider the wall to be a ‘sensitive structure’. The wall would be significantly less sensitive to ground induced vibrations in the order of 100 Hz than the structures described in Line 1 of Table 3.1 above. Adopting a vibration limit of 25 mm/s would be acceptable for the wall.

5. RECOMMENDATIONS

SOTO recommends an observational approach to monitor the effects of blasting at a vibration level of 25 mm/s on the existing wall. During blasting, monitor the effects of blasting on the wall by a program of controlled photography and video records consisting of:

- Baseline condition photos.
- Periodic time review photos.
- Video recording to establish vibration levels at which any rocks become unstable. The 'instability' level (with a safety factor) then becomes the basis for PPV limit blast design.

The management of blast monitoring, measurement equipment and techniques should comply with the Australian Standard AS 2187 Parts 1 and 2 – 2006.

SOTO has issued this letter based on the observations made during our site inspection on 8 October 2014 and the information outlined above. Any changes to the proposed construction that might be instigated by Fulton Hogan or any nominated contractors should be reviewed and approved by authorised personnel only, in accordance with Fulton Hogan's design control procedures. This letter does not alleviate the customer of its relevant statutory obligations in relation to the relevant structure.

If you have any queries please do not hesitate in contacting the undersigned.

For and on behalf of SOTO Consulting Engineers.

David Tarlinton
Senior Structural Engineer
MIEAust CPEng RPEQ

APPENDIX A

Project Title	Fulton Hogan Foxground Berry Bypass Structural Vibration Assessment of Dry Stack Stone Wall
Project number	2014-00235
Inspection Date	8 October 2014
Engineer	R. Minato, J. Caballero
Site Location	455 Princess Highway Broughton Village

SOTO
CONSULTING ENGINEERS

SITE INSPECTION – PHOTOGRAPHIC SUMMARY

Photo #	Element	Comments	Photo
P080223			
P080226			

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P080228			
P080230			
P080231			

P080233			
P080238			
P080239			

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