Construction noise and vibration Impacts from blasting

CASE STUDY

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WATERVIEW CONNECTION PROJECT

The $1.4 billion Waterview Connection Project (Auckland, 2012-2017) will deliver 5 km of new state highway connecting SH20 with SH16, of which 2.5 km will be in tunnels. Comprising of the NZ Transport Agency, Fletcher Construction, McConnell Dowell Constructors, Parsons Brinckerhoff, Beca, Tonkin and Taylor, and Japanese construction company Obayashi Corporation, the Well-Connected Alliance are designing and constructing the new highway.

The importance of managing construction impacts was recognised by the Board of Inquiry appointed to determine the notice of requirement for this project (refer to the *Environmental Protection Authority website* for details). The designation conditions set by the Board included managing the effects of construction on neighbours and the natural environment. In accordance with these conditions, the Well-Connected Alliance measures air quality, noise, vibration and ground movement, both in and around the construction sites. The results are reported monthly on the *project website* and to Auckland Council which monitors compliance with the designation conditions.

The Southern construction zone comprises the above ground works from Maioro Street to the new tunnels, and is located primarily within established residential urban areas with relatively low existing noise and vibration levels. Two elements of the work within this zone that required removal of the underlying basalt rock by blasting or rock breaking were:

- a high-sided trench to take the highway down to the tunnel portals (the Southern Approach Trench); and
- the realignment of the Hendon sewer.

This case study discusses the designation conditions imposed on the project and details some of the implications on these two elements of the work in the Southern Zone. Technical terms used in this case study are explained in the Transport Agency *Construction and maintenance noise and vibration guide*, which also includes an overview of vibration standards referenced.

Designation conditions

Within the designation conditions there are a range of conditions covering construction noise and vibration from the project. Some address noise and vibration from the general works, whilst others specifically address the effects from blasting.

VIBRATION CRITERIA

Condition CNV.4 applies DIN 4150-3 building damage criteria to all of the construction works (excluding blasting), with levels dependent on the type of structure and dominant frequency of the vibration.

CNV.13 acknowledges that CNV.4 may not be met at all times but certification from Auckland Council is required in advance of any exceedances.

To address the effects on human comfort from blasting, Condition CNV.5(a) applies a limit of 5mm/s (95% of blasts) and 10mm/s (100% of blasts), taken from AS 2187-2.

The statistical approach from this standard is usually used to address the vibration effects of long-term quarrying operations.

Furthermore, Condition CNV.5(b) states for work in the Southern Zone, the frequency dependent criteria in CNV.4 must be met for 95% of activities and must be less than 10 mm/s ppv for 100% of activities. This applies to activities identified as being at a 'High Risk' of exceeding the DIN 4150-3:1999 criteria (being excavation, piling, compaction and drilling)' in the assessment report submitted to the Board of Inquiry on construction and operational vibration.

The Project's Construction Noise and Vibration Management Plan (CNVMP) states that conditions CNV.4 and CNV.5 apply to blasting. However, it appears the intent of the conditions was that CNV.5(b) refers to all other construction activities apart from blasting, as the effects from blasting are covered in CNV.5(a).

STATISTICAL APPROACH

Due to the variability of vibration levels measured from a consistent source, a statistical approach to the assessment of the results has been used in the conditions. This is in the form of a 95% confidence level which means that 5% of a measurement sample will be above the reported result. In this manner, the intent is that the inherent variability in construction vibration levels is allowed for, and adaptive management in response to measured data is enabled.

Condition CNV.5(a) requires that '*95% of the blasts undertaken (measured over any twenty blasts on the foundation of any building outside the designation boundary) shall produce peak particle velocities not exceeding 5mm/s...'*. These are a number of ambiguities in this condition that could affect the implementation in practice:

- Which twenty blasts? The last twenty or the twenty with the highest recorded vibration levels?
- Do the twenty blasts apply from within a work area or across the whole project?
- Do the twenty blasts only apply to those measured at a single location or at multiple buildings?
- Are multiple exceedences at different buildings from one blast counted as multiple exceedences or as a single exceedence?

SUMMARY

The complex conditions and ambiguous wording appear to have caused unnecessary controls to be applied to the project. Debate over the requirements and increased cost of demonstrating compliance can arise from complex controls without any significant benefit in terms of environmental outcomes. Model conditions covering construction noise and vibration are provided in the Transport Agency *Construction and maintenance noise and vibration guide.*

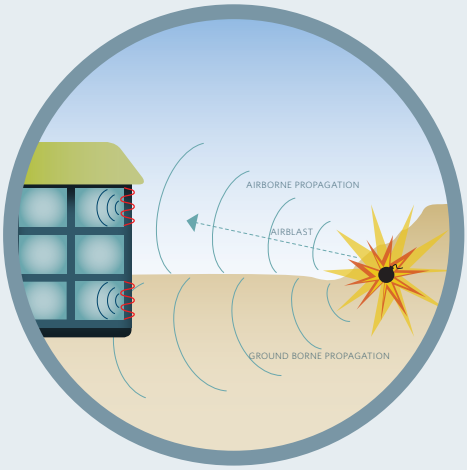
METRICS AND MONITORING

Blasting can give rise to vibration in the ground (ground borne vibration) and a pressure wave in the air (airblast overpressure).

Airblast overpressure is generated at frequencies lower than is typically audible by a human ear, but which can cause subsequent vibrations in buildings giving rise to audible sounds such as windows rattling. This is usually quantified in terms of the peak pressure using the linear frequency-weighting, written as L_{Zpeak} with decibel (dB) units, and is assessed at a free-field location outside a building. Refer to the Transport Agency ***Construction and maintenance noise and vibration guide*** for more information.

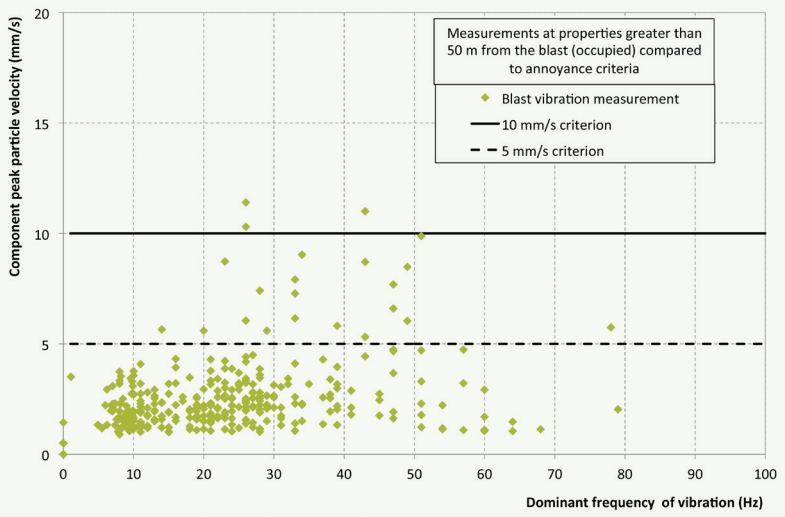
To assess the ground borne vibration from blasting, the peak particle velocity (ppv, typically in mm/s) is used, and is assessed on the foundations of buildings.

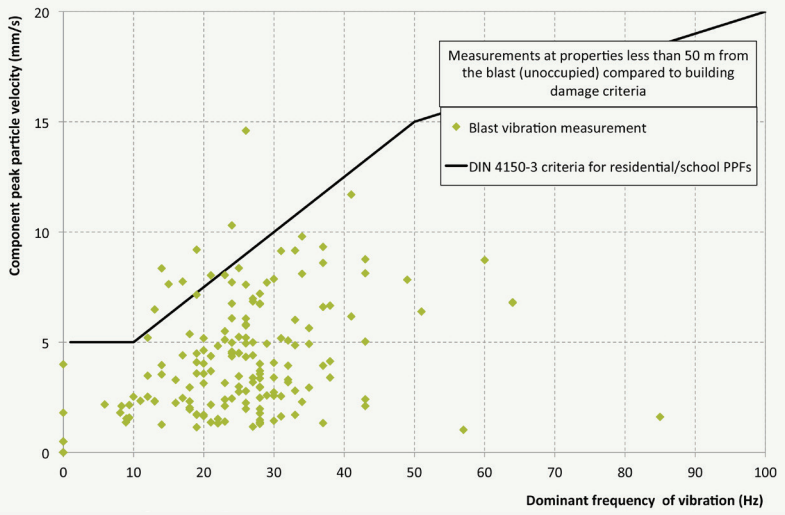
On the Waterview Project, the vibration was measured at buildings using a clamp to couple the transducers to the foundations. For each blast, measurements were simultaneously made at the nearest unoccupied property (less than 50m from the blast) and the nearest occupied property (more than 50m).

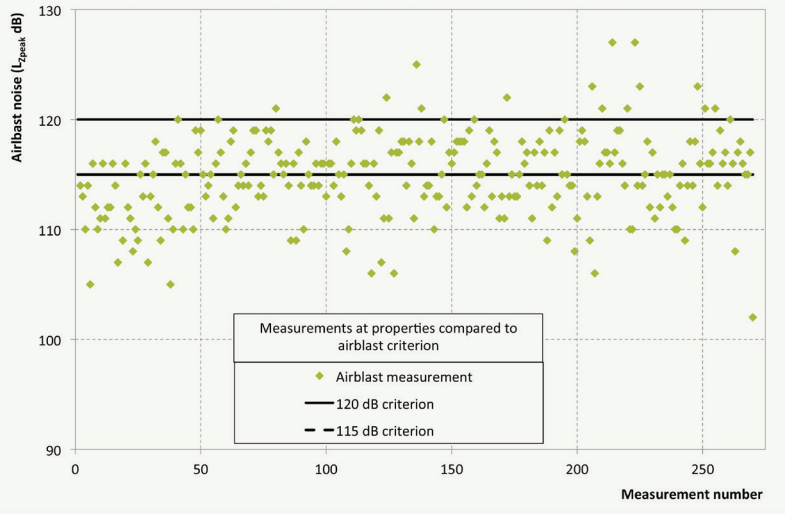


BLAST MONITORING

Between July 2012 and April 2013, 270 blasts were carried out within the Southern Zone and the noise and vibration from all of these was monitored at neighbouring properties. The figures below present the measured vibration and airblast, together with the appropriate criteria. Certification from Auckland Council was obtained in advance where vibration and airblast levels were anticipated to be exceeded.







ROCK BREAKING VERSUS BLASTING

The Hendon sewer diversion required a 5m deep, 2m wide trench to be cut into the basalt adjacent to the boundary of the neighbouring properties, the majority of which were owned by Housing New Zealand (HNZ). This work could have been carried out either by blasting or rock breaking, with one day of blasting being equivalent to approximately five days of rock breaking. As blasting would have exceeded the vibration limits, the Project negotiated with the neighbours to exceed the limits in order to complete the work quickly. Unfortunately, although agreement was obtained from HNZ, such an arrangement could not be made with all of the private owners. Therefore the trench was cut using a rock breaker, with a consequently longer period of work. It is likely that overall noise and vibration effects would have been less for all residents had blasting been used.

Management actions

To manage the noise and vibration effects from the blasting work, a number of management actions were developed and included in the Construction Noise and Vibration Management Plan. These included the following actions:

- Before blasting started, building surveys were offered to all building owners within 90m of a blast location. This survey was of value to the project, as any pre-existing damage could not subsequently be attributed to the vibration from the blasting. Conversely, the surveys also benefitted the owners of the buildings, as any damage resulting from the blasting could be shown not to have existed before work commenced.
- The Project originally planned 50 blasts around the Southern Portal. However, the vibrations from blasts of this size were predicted to significantly exceed the vibration criteria. This was managed by decreasing the size of each blast, which resulted in an increase in the number of blast events.
- Liaison with Auckland Council on construction vibration (amongst other effects) started at the earliest opportunity.
- Arrangements were made for all properties within 50m of a blast to be temporarily unoccupied at the time of each blast. Supermarket vouchers were offered to the residents as compensation for the inconvenience.
- The vibration and airblast from each blast were measured at the nearest unoccupied property (less than 50m from the blast) and the nearest occupied property (more than 50m from the blast).
- Blasts occurred at set times and comprised of a number of explosive charges in a localised area (up to 100 charges).
- Fifteen complaints regarding vibration were received. In each case, these were investigated and measurements offered during the next blast. Five occupants accepted the offer and the subsequent measurements showed that the levels were below the required criteria.
- Additional management measures were used to minimise other effects from this work:
  - The blast holes were drilled using an air drill with additional acoustics treatment.
  - Blast mats were used to prevent fly rock.
  - Site fencing (plywood panels) were extended in height at certain locations to provide increased screening from the noise of specific construction activities.

LESSONS LEARNT

- The conditions placed on the project were ambiguous and open to interpretation, resulting in unnecessary duplicate controls. This could have been avoided by having suitably worded conditions.
- A statistical approach to blasting vibration and airblast limits is not appropriate for variable activities occurring at different locations around a large construction site.
- The cutting of the Hendon sewer diversion took approximately five times as long by rock breaking compared to blasting due to the requirement to meet specific noise and vibration levels. Conditions need to allow for management of noise and vibration effects and not just noise and vibration levels.
- Where noise and vibration limits do not allow for appropriate management of effects, reliance sometimes gets placed on the Council to approve exceedances of the limits. However, the Council is not able to authorise non-compliance with designation conditions so if the conditions do not allow flexibility with respect to noise and vibration limits, any unavoidable exceedances would first require an alteration to the designation conditions.

If you require any additional information, please contact:

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