

Determination 2022/002

**Regarding compliance of as-built timber retaining walls
with the Building Code as it relates to the protection of
other property**

67 Waratah Street, Matua, Tauranga

Summary

This determination considers whether the construction of timber retaining walls complies with Building Code clauses B1 *Structure* and F5 *Construction and Demolition Hazards* as they relate to the protection of other property.

The legislation discussed in this determination is contained in Appendix A. In this determination, unless otherwise stated, references to “sections” are to sections of the Building Act 2004 (“the Act”) and references to “clauses” are to clauses in Schedule 1 (“the Building Code”) of the Building Regulations 1992.

The Act and the Building Code are available at www.legislation.govt.nz. Information about the legislation, as well as past determinations, compliance documents (e.g., acceptable solutions) and guidance issued by the Ministry, is available at www.building.govt.nz.

1. The matter to be determined

- 1.1. This is a determination made under due authorisation by me, Katie Gordon, National Manager Building Resolution, Ministry of Business, Innovation and Employment (“the Ministry”), for and on behalf of the Chief Executive of the Ministry¹.
- 1.2. The parties to the determination are:
 - 1.2.1. G Misson, the owner of the neighbouring property at 17 Hartwell Place, Matua, Tauranga, who applied for the determination (“the applicant”) using the services of an agent (“the agent”).
 - 1.2.2. Tauranga City Council (“the authority”), carrying out its duties as a territorial authority or building consent authority, using the services of a legal advisor.
 - 1.2.3. C Lochhead, B Templeton, and G Elvin, the owners of the property at 67 Waratah Street, Matua, Tauranga (“the owners”), where the retaining walls are located, using the services of a legal advisor.
 - 1.2.4. M Armstrong, the owner of the property at 15 Hartwell Place, Matua, Tauranga (“the neighbour”)².
- 1.3. The persons with an interest to the determination are:
 - 1.3.1. BCD Group Limited, a Chartered Professional Engineer specialising in structural and civil engineering (“Engineer 1”).
 - 1.3.2. BSK Consulting Engineers Limited, a Chartered Professional Engineer specialising in structural and civil engineering (“Engineer 2”).
 - 1.3.3. C Mckenney of Macrich Limited, the builder who constructed the retaining walls (“the builder”).

¹ The Building Act 2004, section 185(1)(a) provides the Chief Executive of the Ministry with the power to make determinations.

² The neighbour is a party for the purposes of section 176(e)(i) of the Act.

- 1.4. This determination concerns the construction of two types³ of as-built timber pole retaining walls located on the owners' property at 67 Waratah Street.
- 1.5. The retaining walls are located close to the northern boundary⁴ with numbers 15 and 17 Hartwell Place.
- 1.6. The design and construction of the retaining walls are the subject of a building consent granted by the authority (reference number 300162). There is a separate building consent (reference number 301200) related to the construction of a new detached residential dwelling at 67 Waratah Street (refer to paragraph 1.13).
- 1.7. The dispute relates to the height of the Type 4 and 5 retaining walls and the slope of the ground below them. The applicant has also raised concerns about the effect of the walls' construction on an existing low-level timber retaining wall located on the neighbouring properties. The applicant believes the as-built walls do not comply with the building consent or the Building Code.
- 1.8. The applicant in this case is not the owner of the property where the retaining walls are located. The applicant is the owner of the neighbouring property at 17 Hartwell Place; this is to the northwest and downslope from where the retaining walls are located. Therefore, under section 176(e)(i) of the Act, the applicant is only entitled to apply for a determination in respect of those clauses of the Building Code that have the purpose of protecting other property⁵.
- 1.9. The applicant has specifically referred to Clauses B1 *Structure*, F4 *Safety from Falling* (refer to paragraph 1.15), and F5 *Construction and Demolition Hazards* as being relevant to the dispute.
- 1.10. The matter to be determined⁶ is whether the as-built timber retaining walls comply with the aspects of the Building Code clauses B1 and F5 that have the purpose of protecting other property. In deciding this matter, I must consider the design and construction of the as-built Type 4 and 5 retaining walls.

³ The building consent details five types of retaining walls (abbreviated to Type 1, 2, 3, 4 and 5). The determination continues this taxonomy by using the term "types" to differentiate between the five retaining walls on the site; two of which are the subject of this determination.

⁴ Building Code Clause A2 – Interpretation: "boundary" means any boundary that is shown on a survey plan that is approved by the Surveyor-General and deposited with the Registrar-General of Land, whether or not a new title has been issued.

⁵ Section 7 – "Interpretation" of the Act: "Other property" – (a) means any land or buildings, or part of any land or buildings, that are – (i) not held under the same allotment; or (ii) not held under the same ownership; and (b) include a road.

⁶ Under section 177(1)(a) of the Act.

Matters outside this determination

- 1.11. The determination application includes references to matters that relate to the Resource Management Act 1991 and Tauranga “City Plan”, which are outside the scope of this determination. I have no jurisdiction under other enactments and this determination only considers matters relating to the Building Act and its regulations.
- 1.12. Of the five different “Types” of retaining walls detailed in the building consent, Types 1, 2 and 3 are not located parallel or adjacent to the boundary with the applicant’s property. As such, I have not considered the design and construction of wall Types 1, 2 and 3 in this determination.
- 1.13. The determination does not discuss the separate building consent (reference number 301200) granted for the construction of the new detached residential dwelling located on the same property as the retaining walls at 67 Waratah Street.
- 1.14. I note that at the time of the application for determination, the building work associated with the building consent 300162 is incomplete (specifically, the safety barrier is yet to be installed). Therefore, the authority has not made a decision to issue a code compliance certificate, and the determination does not discuss this matter further.
- 1.15. Clause F4 – *Safety from Falling* does not relate to the protection of other property and I have not considered this further.
- 1.16. The applicant has also raised issues regarding how the authority performed its duties, including its decision to issue the building consent 300162. The issue of how the authority performed its duties is not included in section 177 of the Act and is therefore outside the scope of this determination. Further, since the applicant is not the owner of the retaining walls or the property on which they are located, they are only considered a party under section 176(e)(i) of the Act. As such, the decision to issue the building consent by the authority is also outside the scope of this determination.

2. The building work

- 2.1. The building work relates to the design and construction of two timber pole retaining walls (annotated as Type 4 and Type 5).
- 2.2. Both retaining walls run in a west-to-east direction and are located towards the northwest corner of the property at 67 Waratah Street (see figure 1).
- 2.3. The lower Type 4 retaining wall is located nearest to the boundary along the north side of the property. The higher Type 5 retaining wall is south of the Type 4 wall, further away from the boundary. The horizontal distance between the Type 4 and 5 walls varies between approximately 1.71m to 1.86m.

- 2.4. There is an existing timber retaining wall on the north side of the boundary, located on the properties of 15 and 17 Hartwell Place. It is unclear exactly when this wall was constructed, but evidence suggests it may have been in 1989. The existing retaining wall varies in height along its length between approximately 0.04m to 1.47m high. It is between approximately 0.84m to 1m (measured horizontally) to the north of the new Type 4 wall.



Figure 1: Site plan – indicative location of Type 4 and 5 retaining walls only (not to scale)

(Note: the dwelling shown at 67 Waratah Street existed prior to building works authorised by building consent 301200 – see paragraph 1.13. Figure 1 does not indicate the existing timber retaining wall located on 15 and 17 Hartwell Place – see paragraph 2.4)

Type 4 and 5 retaining walls

- 2.5. The Type 4 and 5 retaining walls were the subject of a ‘specific engineering design’ by Engineer 1, which was supported by a Producer Statement – Design (“PS1”) dated 6 July 2020. The PS1 was for a “retaining structure design...in respect of the requirements of Clause B1 [*Structure*] of the Building Code”.

- 2.6. The design also included structural calculations, plans, specifications, and a geotechnical assessment report (revision 2, dated 5 June 2020). In respect of the “retaining structure design”, the geotechnical assessment report discussed:
 - 2.6.1. that the new retaining walls are to be cantilever timber pole modelled (using specialist software) as flexible walls, and anchored timber pole walls modelled as stiff walls
 - 2.6.2. the soil parameters used in retaining walls design
 - 2.6.3. the retaining walls were checked for factor of safety against overturning, pole bending, shear capacity and deflection, and no wall displacement factors were applied to either walls for seismic design
 - 2.6.4. the poles and timber are to be treated, and steel [ground] anchors have been designed for 100-year durability
 - 2.6.5. the retaining wall will...exceed a 50-year design life which reflects the location and construction difficulty
 - 2.6.6. the design is for a 2m high anchored wall [Type 4] on the north boundary, and a 2.2m high free standing (non-anchored) wall [Type 5] above the anchored wall. There is a 1.5m setback between the walls, and a further 7.5m setback to the proposed new dwelling
 - 2.6.7. the pole depths for the northern wall [which are] governed by global slope stability, and the pole lengths are required to be 9m to achieve a target factor of safety against global stability
 - 2.6.8. the slope height (below the walls) is approximately 8m with a typical slope angle between 27 and 45 degrees.
- 2.7. The geotechnical assessment report also included reference to “safety in design”. The report stated:
 - 2.7.1. the contractor should consider a construction method which uses excavators with a long reach to minimise the load on slope crests, as well as the weight of the machinery used. Lighter machinery is preferable
 - 2.7.2. hand operated compaction equipment should be used to compact the fill
 - 2.7.3. heavy equipment, machinery and construction material should not be stored or parked within 3m of the slope crest.
- 2.8. The geotechnical assessment report did refer to the “existing retaining wall” close to the “northern property boundary”. The report did not provide details about the construction and general condition of the existing wall. However, it was referenced in the “slope stability analyses” in Appendix C of the report.

- 2.9. The original building consent plans include design criteria for the retaining walls, and this is summarised in Appendix B, table 1. A typical cross-section through the construction is in figure 2.

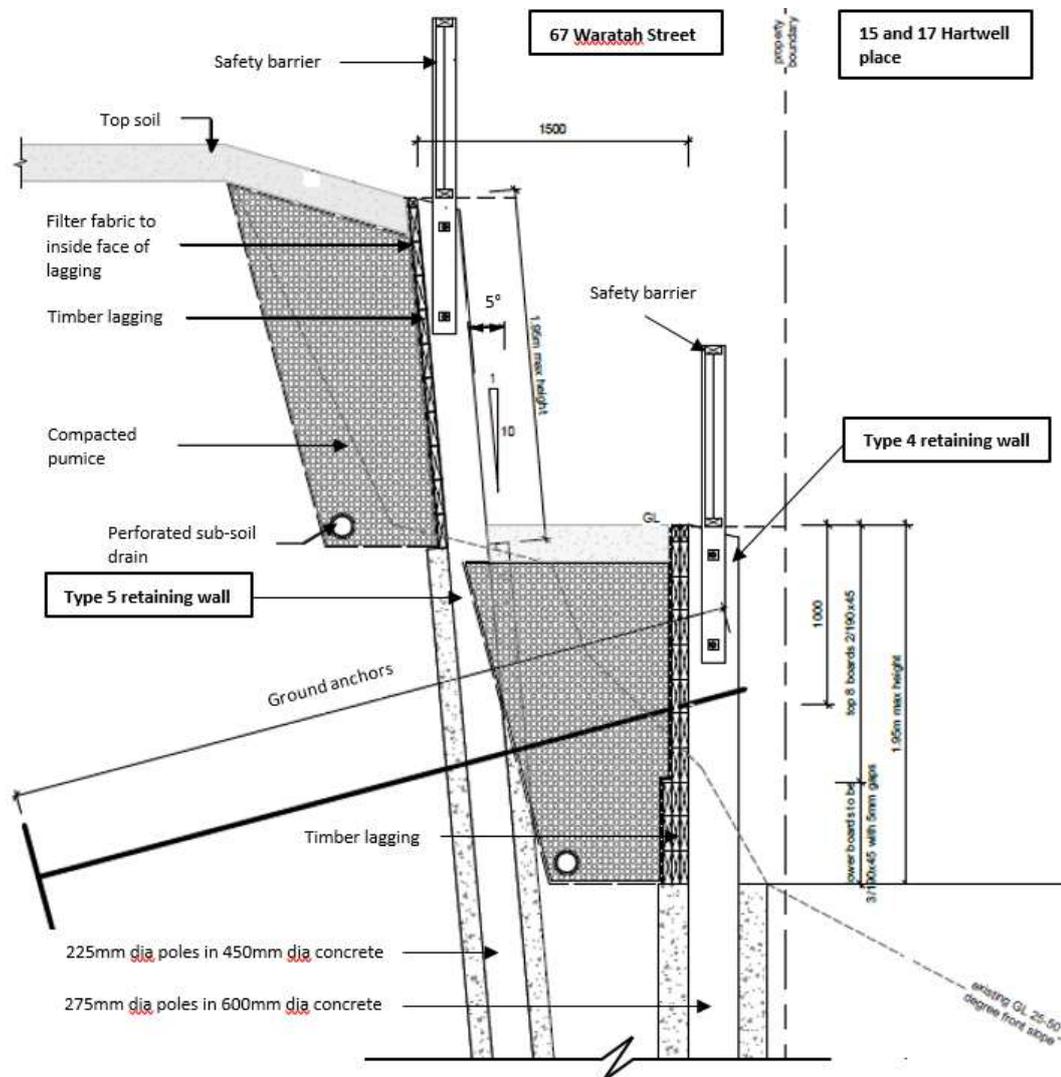


Figure 2: Typical cross-section through retaining wall Types 4 and 5 (not to scale)

(Note: the original design specified the poles were to be spaced 1200mm apart, and the ground anchors were to be 25mm in diameter)

3. Background

- 3.1. The owners applied for a building consent for the new retaining walls on 24 January 2020.
- 3.2. The authority granted and issued the building consent (reference number 300162) on 28 July 2020.

- 3.3. The building work commenced in August 2020.
- 3.4. On behalf of the owners, Engineer 2 conducted a number of site inspections between 13 August 2021 and 6 May 2021 as the building work progressed. A summary of the engineer's observations is in Appendix C, table 2.
- 3.5. The authority conducted a site inspection on 13 November 2020. In its report to the owners, the authority confirmed the inspection outcome was "Fail". The authority's report confirmed:
- The size of the timber lagging had been changed from 190mm high boards to 150mm.
 - The Type 5 wall has been constructed using 250mm diameter timber poles.
 - The northeast end of the retaining wall is "different from the approved consented plans".
 - The height of the Type 5 retaining wall has been increased to 2.1m, from 2.0m, and therefore "differs from the consented plans".
 - The spacing between the poles used for the Type 5 wall is between 900mm and 1400mm and therefore "differs from the consented plans".
 - The northeast corner posts are spaced apart at 1.5m centres, and are approximately 2.4m high.
 - The retaining walls are 1.67m apart, which differ from the consented plans, which indicate 1.5m.
 - The requirement for an amendment to the building consent which is to include "new as-built drawings...a new Engineers PS1 and calculations to demonstrate compliance with [Building Code clause] B1".
 - The location of the walls "appears correct" but this will depend "on the new as built plans that are required".
- 3.6. The authority's inspection report from 13 November 2020 included photographs that show the extent of the as-built construction (refer to figures 3 and 4 for two examples).



Figure 3: Lower view of walls **Figure 4: Mid-level view of walls**

(Note: both figures 3 and 4 are views of the walls looking in an easterly direction)

- 3.7. Prior to 13 January 2021, the owners applied for an amendment to the building consent 300162. The amendment was for “alterations to retaining wall spacing, lagging, tie-in details, anchors, [and] fencing”.
- 3.8. Engineer 2 provided a summary of the changes that it had authorised as the building work progressed. The relevant changes are summarised in Appendix D, table 3.
- 3.9. In support of the amendment application to the building consent, Engineer 2 also provided an amended set of as-built plans (revision D), dated 19 February 2021, a memo dated 17 December 2020⁷, and PS1 dated 18 December 2020⁸. Engineer 1 also provided a Producer Statement – Design Review (“PS2”).
- 3.10. The as-built plans indicate several changes compared against the original design. The relevant differences are summarised in Appendix B, table 1.
- 3.11. The as-built plans did not indicate an angle for the slope to the north, and downhill, from the Type 4 retaining wall but they did state that the “approximate [ground level] (varies)”.
- 3.12. The PS2 from Engineer 1 was in respect of the amended timber pole retaining wall design dated 9 February 2021. A letter dated 22 December 2020 accompanied the PS2, along with a design review log.
- 3.13. Engineer 1 confirmed “...that the minor variations in design from the original design are fit for purpose and consider the tiered timber pole system will meet the

⁷ The memo from Engineer 2 (reference number 23489 Revision 1) included responses to each item indicated in the authority’s inspection report dated 13 November 2020, and structural calculations.

⁸ The PS1 was in respect of “timber retaining wall amendments” and confirmed it met the requirements of Building Code clause B1.

Building Code ([Clause] B1) requirements once the remedial works...are undertaken” (as indicated in the report and plans provided by Engineer 2).

3.14. The authority approved the building consent amendment on 17 March 2021.

3.15. The Ministry received an application for a determination on 15 March 2021.

4. Submissions

The applicant – 17 Hartwell Place

4.1. On 25 September 2020, the applicant’s legal advisor informed the authority of “non-complying building works” with regard to the Type 4 and 5 retaining walls, and that “immediate action [was] required”. The legal advisor stated:

- the design incorrectly records the existing ground level well above that of the actual ground level at the site
- the design neglects to show the existing 1m retaining wall, which is on the boundary of the two properties.

The letter from the legal advisor also included photographs prior to, and after, the construction of the retaining walls (figures 5 and 6).



Figure 5: “Before”

Figure 6: “After”

(Note: The building at 67 Waratah Street, as pictured in figure 5, is that which existed prior to its demolition and the construction of a new dwelling – see paragraph 1.13)

4.2. The agent wrote several letters to the Ministry in support of the application for determination. The content of these letters is summarised in Table 4⁹.

⁹ I note the letters dated 29 September 2020 and 8 October 2020 pre-date the application for determination on 15 March 2021.

Table 4: Summary of points raised by the agent on behalf of the applicant

Date of letter	Summary of items raised
29 Sept 2020	<ul style="list-style-type: none"> • The matter for determination relates to “the height of the timber pole retaining wall structure” • The design height of the wall is 2m • From an inspection and site survey, the height “of the retaining wall is in the order of 3.28m, with the building structure on the boundary now...proposed to be over 4m in height” • “The actual site slope profile taking into account the existing low old landscaping retaining wall, has not been taken into consideration in the building consent” • “As a result of the failure to consider the actual physical conditions, the building consent has been issued by the [authority] contrary to the requirements of the Building Code, [and] the Building Act...” • The authority “has allowed the building work to continue otherwise in accordance with the building consent”.
8 Oct 2020	<ul style="list-style-type: none"> • Included reference to those Building Code clauses “in respect of protecting...other property” - namely B1.1, B1.2, B1.3.1, B1.3.3 and B1.3.4 • The determination relates to section 177(1)(a)¹⁰ of the Act • The “old low retaining [wall] of 1m height immediately in front of the retaining wall...has not been taken into account of in the design and construction of the retaining wall” • The height of the retaining wall and slope of the ground in front of it is “greater than is detailed and specified in the...design” • “The retaining wall...has a high probability of structural failure that would cause risk to [the] other property below...” • “Proper account has not been taken of the physical conditions that affect the stability of the retaining wall...” • The application for determination also relates to section 177(1)(b) of the Act in respect of the issue of the building consent (refer to paragraph 1.16).
15 Mar 2021	<ul style="list-style-type: none"> • This letter accompanied the application for determination, and repeated many of the issues raised in the agent’s correspondence dated 29 September 2020 and 8 October 2020 • It queried “the foundation tie backs” (ground anchors) which it stated were 8m long, but the new dwelling at 67 Waratah Street was 7.3m from the top of the retaining wall, “thus the retaining wall...is providing the foundation support to the dwelling...”

¹⁰ S177(1)(a): A party may apply to the chief executive for a determination in relation to...(a) whether particular matters comply with the building code...

	<ul style="list-style-type: none"> The continued construction on site was “creating a dangerous and hazardous risk of injury and damage” (the letter did not state who was at risk of injury, or what was at risk of damage).
31 Mar 2021	<ul style="list-style-type: none"> It stated “...the safeguard of other property from damage is also provided for under [Building Code clause] F5” and “compliance has not been demonstrated...in the building consent, for the construction and/or demolition that is a likely eventuality, to achieve a complying building structure” It noted the authority’s failed inspection, and a requirement for an amendment to the building consent, and that “...the key design height element...has been ignored and still has not been addressed” Provided an attached site survey plan “...which demonstrates the missing survey data that the design engineers have excluded from their stability analysis of the retaining wall...”.
23 Apr 2021	<ul style="list-style-type: none"> Considered that “...as the wall provides the mechanism to retain and stabilize the foundation ground to the dwelling...that is immediately above the wall...” this is ‘restricted building work’¹¹ Requested that the ongoing building work to construct the new dwelling at 67 Waratah Street “...be suspended under [section] 183¹² of the Building Act...” due to “the on-going risk to the protection of other property”.
3 May 2021	<ul style="list-style-type: none"> This letter was in response to comments made by Engineer 2 (refer to paragraph 4.10), and repeated many of the items raised in the agent’s previous letters “The older retaining wall is now exhibiting signs of failing”.

The owner – 67 Waratah Street

- 4.3. On 30 April 2021 a legal advisor engaged by the building owner stated that they oppose the agent’s submission, and that “there is no evidence...of an ‘ongoing risk’ or ‘exacerbated risk’ as submitted”. The owner relies “on the submission filed by” Engineer 2 (refer to paragraph 4.10).

The neighbour – 15 Hartwell Place

- 4.4. In an email to the Ministry dated 31 May 2021, the neighbour stated “the measures decided are designed to further protect [the neighbour’s] property”.

¹¹ Section 7 – *Interpretation of the Act*: **restricted building work** means any building work that is—
 (a) building work of a kind declared by the Governor-General by Order in Council to be restricted building work; or
 (b) design work of a kind declared by the Governor-General by Order in Council to be restricted building work. See: *Building (Definition of Restricted Building Work) Order 2011*.

¹² Section 183 – Decision or exercise of power suspended until determination made.

- 4.5. In a further email to the Ministry dated 23 June 2021, the neighbour stated “the work that has been done has been done properly...[and they didn’t] see any reason why the work cannot proceed”.

The authority

- 4.6. On 14 April 2021, in response to a request for further information from the Ministry, the authority confirmed it had received an application for an amendment to the building consent for the retaining walls. The authority also confirmed it had not yet conducted any other site inspection since the 13 November 2020 (refer to paragraph 3.5).
- 4.7. On 17 May 2021, a legal advisor engaged by the authority confirmed that the application to amend building consent 300162 was received from the owners on 23 December 2020. The authority subsequently issued the building consent amendment on 22 March 2021¹³.
- 4.8. On 18 May 2021, the legal advisor confirmed that the authority had not issued a code compliance certificate¹⁴ for building consent 300162.

Engineer 1

- 4.9. In an email to the Ministry, dated 24 March 2021, Engineer 1 declined to make a submission “at this time”.

Engineer 2

- 4.10. On 30 April 2021, Engineer 2 responded to the points raised by the agent in their letter dated 15 March 2021 (refer to paragraph 4.2). Engineer 2 confirmed:
- they took into consideration the existing 1m high timber retaining wall on the neighbour’s property, and the slope of the ground below it, when they assessed the stability analysis of the Type 4 and 5 retaining walls
 - they indicated that the slope of the ground below the retaining walls, as annotated on the design plans, was “approximate”. They based this on information available from the authority’s smoothed lidar¹⁵ surface data, which provides an ‘average’ set of results
 - they acknowledged the new survey data provided by a registered surveyor was attached to the agent’s letter. This included information on “new levels for the new retaining wall and the older walls beneath”. It also confirmed that the slope angle below the retaining walls “is 25 degrees and

¹³ I note the date provided by the legal advisor of 22 March 2021 does not match the date of 17 March 2021 stamped by the authority on the approved amended plans (refer to paragraph 3.14).

¹⁴ Section 95 of the Act.

¹⁵ Lidar – acronym for “Light Detection and Ranging” or “Laser imaging, detection and ranging”.

is shallower than the slope angle modelled in the design. This would act to improve the wall performance”

- the old retaining wall “was not included in the original design, nor amendments because [Engineer 2] wished to establish cases that are worse than the current condition. This would allow for future failure of the older retaining wall...”.

- 4.11. On 18 May 2021, Engineer 2 confirmed they had yet to complete their inspections and issue a Producer Statement - Construction Review (PS4) as the building work is incomplete. However, they conducted several inspections as the construction of the retaining walls progressed (see Appendix C, table 2).
- 4.12. Engineer 2 also stated, “All items to maintain site stability are in place to allow the [dwelling] construction and the safety fence remains in place. The only remaining items for construction are for the safety from falling [barrier] and landscaping (fence and planting)”.

The builder

- 4.13. On 26 June 2021 the builder confirmed, “The walls to be constructed in accordance to the building consent”, and the items left to complete were some planting “on the top of the lower [Type 4] wall” and the installation of “a permanent safety fence on the top of the [Type 5] wall”.
- 4.14. On 7 July 2021, the builder provided a number of photographs that show, in part, the Type 4 and 5 retaining walls at various stages of construction. The builder also provided a “work record and test results” for the ten 20mm diameter ground anchors that have been installed.

5. Expert’s report

- 5.1. The Ministry engaged the services of a firm of chartered professional engineers with structural and geotechnical expertise (“the expert”) to assist it with a technical review of the Type 4 and 5 as-built retaining walls. The review included an assessment of the plans and specifications¹⁶ related to building consent 300162 and a requirement to conduct a site visit.

Site visit and findings

- 5.2. The site visit was conducted on 7 July 2021. A firm of registered professional land surveyors (“the surveyor”) also attended, whom the expert engaged and directed. The surveyor was responsible for taking vertical datum heights and horizontal measurements to establish the location of the retaining walls relative to the

¹⁶ Section 7 – Interpretation: “Plans and specifications” – (a) means the drawings, specifications, and other documents according to which a building is proposed to be constructed....

property boundary, the existing retaining walls, and the owner's new dwelling, as well as the ground levels and contours associated with, and in the immediate area of, the building work.

- 5.3. On 19 August 2021, the expert issued a report¹⁷ of its findings to the Ministry. The Ministry issued a copy to the parties and persons with an interest on 20 August 2021. The survey plans prepared by the surveyor were included with the report.
- 5.4. The expert's report included (but was not limited to) the following:
 - 5.4.1. A general description of the Type 4 and 5 retaining walls, their location, reference to the building consent, and current status of the as-built construction.
 - 5.4.2. Confirmation that the Type 4 and 5 retaining walls each "retain height of approximately 2.0m, for a combined retained height of approximately 4m".
 - 5.4.3. A review of the structural calculations (that had been prepared using a specialist wall analysis software program) in support of the specific engineering design of the retaining walls for the building consent. The report noted "a number of discrepancies...in the...analysis". It gave a description of the "item" assessed, and stated where specific structural loadings, deflections, resistance values, and wall forces had been either 'underestimated' or 'overestimated' in the calculations.
 - 5.4.4. The report noted that the construction sequence adopted in the original design was the opposite to how the walls were actually built on site. The actual sequence involved a "temporary cut followed by wall installation followed by backfilling with pumice fill".
 - 5.4.5. The expert had carried out their own retaining wall analysis checks using another specialist software program "to assess the impact of the difference between the...construction sequence adopted by the retaining wall designers and the as-built...construction sequence" used on site. They had also taken into consideration any elevated groundwater pressure, the existing downslope profile based on the recent topographical survey by the surveyor, and any compaction induced earth pressures of the backfill behind the retaining walls.
 - 5.4.6. They confirmed that "the results of [their] independent design check indicate that the design actions for both the Type 4 retaining wall and Type 5 retaining wall do not exceed the structural design capacity of [the] timber poles or [the] timber lagging".

¹⁷ Technical report reference 281320-10-REP-01-Waratah, Final-01, dated 19 August 2021.

- 5.4.7. They confirmed an assessment of the expected loadings and capacity of the 20mm diameter ground anchors used, and considered they were “acceptable from a structural perspective”.
- 5.4.8. They considered that “the slope stability assessment¹⁸ carried out by [Engineer 1] to be conservative compared to the as-built retaining wall, resulting in an acceptable retaining wall solution”.
- 5.4.9. The report included a summary that stated, “Despite the discrepancies in the analysis undertaken by the retaining wall designer..., the Type 4 and Type 5 retaining wall as built, are considered to meet the requirements of Clause B1 [Structure] of the New Zealand Building Code”.

Protection of other property

- 5.5. The expert’s report also addressed specific matters of compliance with the Building Code that have the purpose of protecting other property. The following points were noted:
 - 5.5.1. Adequate provision has been made to protect the downslope property from physical damage caused by structural failure of the new Type 4 and 5 retaining walls and comply with Building Code clause B1.1(c).
 - 5.5.2. The as-built retaining walls have been designed with tolerable discrepancies in the design calculations and constructed to withstand the combination of loads they are likely to experience throughout their lives and comply with Building Code clause B1.2.
 - 5.5.3. The Type 4 and Type 5 retaining walls have been designed for both static and seismic load combinations as per AS/NZS1170.0¹⁹, and with appropriate load factors.
 - 5.5.4. The as-built...retaining walls [have] been designed...and constructed such that they have a low probability of rupturing, becoming unstable, losing equilibrium, or collapsing through their lives and comply with Building Code clause B1.3.1.
 - 5.5.5. The expert considered that “the as-built retaining walls [have] been designed...and constructed such that account has been taken of all physical conditions likely to affect the stability of the walls and comply with Building Code clause B1.3.3”. The expert noted that the “relevant physical conditions include”:

¹⁸ Geotechnical assessment report, revision 2, dated 5 June 2020 (refer to paragraph 2.6).

¹⁹ Australia / New Zealand Standard AS/NZS 1170.0:2002 *Structural design actions – Part 0 - General principles*.

- Imposed gravity loads arising from use, specifically the handrail above the Type 5 wall which “has yet to be constructed” (clause B1.3.3(b)).
- Earth pressure (clause B1.3.3(d)).
- Water and other liquids (clause B1.3.3(e)).
- Earthquake (clause B1.3.3(f)).

5.5.6. The expert considered that “the as-built retaining walls have been designed...and constructed such that due allowance has been made for the consequences of failure whilst considering the intended use of the building and that they comply with Building Code clause B1.3.4”. The expert noted that “as the retaining wall has sufficient structural design capacity, ground anchors are not expected to be over loaded, and the slope is stable under both static and seismic conditions,...[that] the consequence of failure to be low”.

5.5.7. The expert also considered compliance with clause B1.3.6(b), which states that sitework, where necessary, shall be carried out to avoid the likelihood of damage to other property. The expert referred to photographs provided by Engineer 2 and the builder and noted:

A temporary plastic covering was placed over the existing fence to the north of the Type 4 retaining wall during the preparation and construction of the new retaining walls. The vegetation immediately downslope of the existing retaining walls appears to be untouched by [the] earthworks

The condition of the existing retaining wall appears to be of [a] similar condition to that prior to construction

Site preparation and construction upslope of the existing wall effectively unloaded the wall, resulting in less forces acting on the existing retaining wall.

5.5.8. The expert considered that “the as-built retaining wall complies with the performance requirements of the Building Code for clause B2 – “Durability”. In reaching that point of view, the expert referred to information obtained from the PS1 provided by Engineer 1, as-built plans from Engineer 2, and the supplier of the “structural timber poles”. This included information about timber treatment in compliance with

NZS 3640:2003²⁰, and mild steel structure and protective coatings in accordance with AS/NZS 2312:2014²¹ and SNZ TS 3404:2018²².

Comparison of as-built plans and topographical survey

5.6. The expert compared the as-built plans provided by Engineer 2 with “the results of the topographical survey” by the surveyor. The expert identified several differences, including (but were not limited to):

- The retained heights of the Type 4 and 5 walls “were generally higher than those detailed on the as-built drawings”. The expert noted that the retained height of the wall varied from 0.45m up to a maximum of 2.06m for the Type 4 wall, and from 1.97m up to a maximum of 2.07m for the Type 5 wall
- Differences in the spacing between poles
- The distance the ground anchors “were installed below the top of the retaining wall poles was [generally] less than those detailed on the as-built drawings”
- The horizontal distance between the Type 4 and 5 walls varied between 1.71m to 1.86m, which was “greater than the 1.67m specified on [the] as-built drawings”
- The expert provided a copy of the as-built plans prepared by Engineer 2 and indicated “mark ups” to highlight the differences they had observed.

5.7. The expert confirmed the extent of the varying angle of the slope on the downhill (north) side of the existing retaining wall located nearest to the Type 4 wall. This information was shown on the relevant survey plan prepared by the surveyor. The angle of the slope varied between 24.2 degrees to 33.8 degrees.

5.8. The expert stated, “[t]he angle adopted for the retaining wall design is based on the 1m high existing retaining wall being ignored”.

5.9. The expert considered that “the dwelling does not impose any additional loading onto either the Type 4 and 5 retaining wall (including the ground anchors)”. They noted the as-built horizontal distance between the walls and the dwelling (between 9.7m to 10.0 from the Type 4 wall) compared against the lesser value of 7.5m allowed for in the “slope stability analysis” by Engineer 1. The expert had also considered that the load testing of the ground anchors was “approximately

²⁰ New Zealand standard NZS 3640:2003 *Chemical Preservation of Round and Sawn Timber*.

²¹ Australian / New Zealand Standard AS/NZS 2312.2:2014 *Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings, Part 2, Hot dip galvanizing*.

²² Standards New Zealand Technical Specification SNZ TS 3404:2018 *Durability requirements for steel structures and components*.

equal” to the demand, and that at a depth of “at least 3.9m below finished ground level” any “vertical pressure applied by the new dwelling is not expected to adversely impact the ground anchors”.

The existing retaining wall

5.10. The expert assessed whether the stability and structural integrity of the existing timber retaining wall immediately downslope (north) of the Type 4 wall may have been affected by the building work. The existing retaining wall is located on the properties of 15 and 17 Hartwell Place. The expert confirmed the following:

5.10.1. The construction of the existing retaining wall as “a timber cantilever retaining wall, with both the poles and lagging constructed of half rounds”

5.10.2. The diameter of the half rounds range “between 160 to 180mm”

5.10.3. That “the retaining height of the existing retaining wall ranges between 0.0 to 1.4m”

5.10.4. The existing wall “varies in its degree of deterioration”. This included that some of the timber “poles had rotated inward, while others had rotated outward”, and the “horizontal lagging was observed to follow the rotation of the...poles”. See figures 7 and 8.



Figure 7: Westerly view

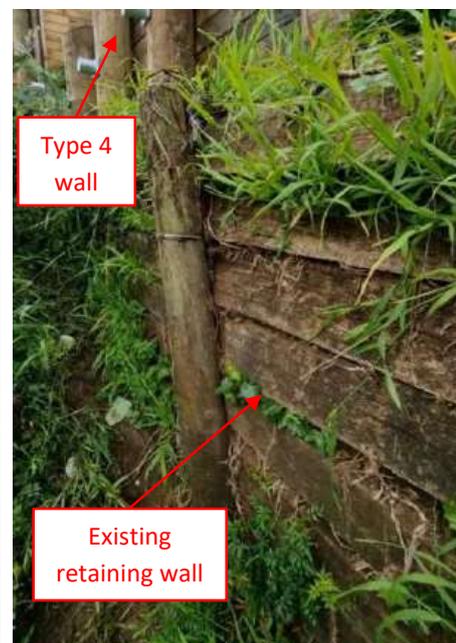


Figure 8: Easterly view

5.10.5. A photograph provided by the builder, taken prior to the commencement of the building work, shows “the existing retaining wall appears to be in a poor condition” (see figure 9).



Figure 9: Westerly view prior to commencement of the building work

5.10.6. The expert also noted:

It is possible that the 600mm diameter augered holes, for the Type 4 retaining wall,...may have disturbed the soil immediately adjacent to the existing retaining wall.

The existing retaining wall is no longer providing support for the above slope and is now limited to providing support to the narrow width of soil between it and the Type 4 retaining wall. The existing retaining wall is expected to be founded at a relatively shallow depth (based on the observed rotation of the half round poles) and provides no resistance to global instability of the slope (global stability is now provided by the Type 4 and 5 retaining walls). Effectively, the existing retaining wall is no longer serving its original purpose of providing support to the above slope and is redundant.

...the existing retaining wall had limited stability and structural integrity when Building Consent 300162 was granted, and has not lost any further stability or structural integrity as a result of the construction of the new Type 4 and 5 retaining walls”.

Expert's addendum report

- 5.11. After the expert's report was issued, the Ministry sought additional information in respect of the durability of the ground anchors used in the construction of the Type 4 retaining wall.
- 5.12. The additional information was sought due to the reduced size of the ground anchors (from 25mm diameter bars in the original design, down to the actual 20mm diameter bars installed on site)²³. See Appendix B, table 1, and paragraph 5.4.7. The expert was asked to consider:
- 5.12.1. the permeability and corrosivity of the supported soils at the site
 - 5.12.2. the nature of the anchorage system, particularly the corrosion coatings used on the ground anchors
 - 5.12.3. the manner in which the ground anchors were installed
 - 5.12.4. the potential failure of the ground anchors over 50 years
 - 5.12.5. the design load in the anchors, and the margins available for the loss of the steel cross section over time due to potential corrosion
 - 5.12.6. how the design compares with the ground anchors suppliers' recommendations to ensure durability
 - 5.12.7. the impact of the reduction in the diameter of the ground anchors in the installed condition
 - 5.12.8. Standards New Zealand Technical Specification SNZ TS 3404:2018 *Durability requirements for steel structures and components*²⁴
 - 5.12.9. Australian / New Zealand Standard AS/NZS 2312.2:2014 *Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings, Part 2, Hot dip galvanizing*²⁵.
- 5.13. The expert issued an addendum report²⁶ to the Ministry on 10 January 2022, which was sent to the parties and persons with an interest on the same day.
- 5.14. The expert considered:

²³ The reduced size of the ground anchors was authorised by the authority when it granted the amendment to the building consent (see paragraph 3.14).

²⁴ SNZ TS 3404:2018 is a cited document in Acceptable Solution and Verification Methods for New Zealand Building Code Clause B2 Durability, amendment 12, effective from 28 November 2019.

²⁵ AS/NZS 2312.2:2014 is cited in, and to be read together with, SNZ TS 3404:2018.

²⁶ Expert's reference: 281320-10-REP-01-Waratah, addendum-03.

- 5.14.1. the change to the anchor design, and noted the differences between the specification of the anchors in the original “consented design details” compared to the “as-built details”
- 5.14.2. the incorrect protective coating thickness stated in the geotechnical assessment report provided by Engineer 1²⁷
- 5.14.3. the permeability and corrosivity of the supported soils at the site. Based on the documentation provided, Engineer 1 did not carry out any site-specific soil testing to help inform the exposure conditions for the ground anchor design, and noted that “this is recommended but not an essential requirement for compliance with SNZ TS 3404”
- 5.14.4. the backfill used at the site behind the retaining walls is “expected to have at most an Exposure Classification of ‘Mild’ according to Table 12²⁸ of SNZ TS 3404, based on Soil Condition B²⁹ as per Note b of Table 12”
- 5.14.5. a revised corrosion calculation based on the original calculation by Engineer 1, then taking into consideration an exposure classification of ‘mild’ and soil condition B. The expert calculated a corrosion rate of 1.52mm per side over a 100 year design life
- 5.14.6. the “suppliers’ recommendations for durability”, and noted “it is not common to use epoxy coated bars, but instead allow a certain amount of sacrificial corrosion to take place once the galvanising coating has oxidised”
- 5.14.7. the ground anchor installation and load testing performed on site
- 5.14.8. the impact of reduced anchor size and potential failure over 50 years, and stated the ground “anchors installed at the site are designed to ‘fail’ in bearing (soil bearing failure) before structural failure of the anchor”
- 5.14.9. “the reduction in bar diameter from 25mm to 20mm (36% reduction in cross sectional area) [was] acceptable given the residual tensile capacity of a 20mm [diameter] bar in a corroded state” (ie 15mm diameter)
- 5.14.10. ground anchor settlement induced loading, and concluded that the structural check that had been presented in the expert’s original report dated 19 August 2021, for “a steel bar in a corroded stated (15mm dia)” is “the worst-case scenario based on the anchor head bearing exposed to atmospheric conditions”. In this respect, the expert’s original report stated “that up to 65mm of backfill settlement is tolerable before the [ground

²⁷ Engineer 1 stated HDG900 hot dip galvanised 900 microns thick. The expert noted HDG900 equates to galvanising of 900g/m², which corresponds to a coating thickness of 125 microns.

²⁸ Table 12: *Exposure classification for steel in soil*.

²⁹ Note b: High permeability soils (such as sands and gravels) that are in groundwater or all soils above groundwater.

anchor] is overstressed” and “the likelihood of this magnitude of backfill settlement occurring is considered very low”.

6. Draft determination

- 6.1. A draft determination was issued to the parties and persons with an interest on 3 November 2021.
- 6.2. The legal advisor for the owners responded on 3 November 2021. They confirmed that the draft determination is accepted subject to non-contentious comments regarding the ownership of the property at 67 Waratah Street. The legal advisor confirmed there were two other parties who owned the property in addition to the one identified in the application for determination (ie there are three owners in total. See paragraph 1.2.3). The Ministry wrote to the legal advisor on 4 November 2021 to establish whether the two other parties were aware of the application for determination, that they had received copies of all the documentation associated with it, and invite them to respond to the draft. The legal advisor responded on 4 November 2021 to confirm he was acting on behalf of all three owners when he responded on 3 November 2021; this was confirmed by the two other parties separately on 4 November 2021 and 5 November 2021.
- 6.3. The agent, acting on behalf of the applicant, responded to the draft determination on 22 November 2021. The agent confirmed they had “no further comment to make on the draft determination”.
- 6.4. The legal advisor for the authority responded to the draft on 19 November 2021. They confirmed that the authority had “nothing to add to the draft determination”.
- 6.5. The neighbour (15 Hartwell Place) responded to the draft determination on 22 November 2021 and confirmed acceptance of it.
- 6.6. Engineer 1 and Engineer 2 were contacted by the Ministry on 22 November 2021, and both declined to formally respond to the draft determination.
- 6.7. The builder responded to the draft determination on 23 November 2021 and confirmed he was in agreement “with the findings and outcome”.

7. Discussion

- 7.1. The matter for determination is whether as-built timber retaining walls comply with the aspects of Building Code clauses B1 and F5 that have the purpose of protecting other property.
- 7.2. The agent has specifically referred to matters of compliance with Clauses B1 *Structure* and F5 *Construction and Demolition Hazards* (refer to Appendix A).

- 7.3. The item of dispute relates to the height of the Type 4 and 5 retaining walls, and the slope of the ground below them. The applicant believes the as-built walls do not comply with the building consent or the Building Code.
- 7.4. The applicant has also raised concerns about the effect the construction of the new Type 4 and 5 walls has had on an existing low-level timber retaining wall located on the neighbouring properties at 15 and 17 Hartwell Place.

Legislation

- 7.5. The purpose of the Act³⁰ is:
To promote the accountability of owners, designers, builders, and building consent authorities who have responsibilities for ensuring that building work complies with the Building Code.
- 7.6. The principles to be applied in performing functions or duties, or exercising powers, under the Act include³¹:
the need to provide for the protection of other property from physical damage resulting from the construction, use, and demolition of a building.
- 7.7. Section 17 of the Act states:
All building work must comply with the building code to the extent required by this Act, whether or not a building consent is required in respect of that building work.

The height of the retaining walls

- 7.8. In their letter dated 29 September 2020, the agent stated that the matter for determination relates to the height of the retaining wall structure, which is “greater than is detailed and specified in the...design” (ie 2m high). Referring to an inspection and site survey, the agent stated the height “of the retaining wall is in the order of 3.28m” and now “proposed to be over 4m” high.
- 7.9. The authority noted in its inspection report from 13 November 2020 that the height of the Type 5 retaining wall has been increased to 2.1m on site, from a design height of 2.0m.
- 7.10. The plans from Engineer 1 that accompanied the original building consent confirm that the Type 4 retaining wall is to vary in height up to a maximum of 1.95m above ground level. The maximum retained height is 4.0m.
- 7.11. The same building consent plans indicate the Type 5 retaining wall was to up to a maximum of 1.95m high above ground level, and the maximum retained height is 2.2m.

³⁰ Section 3(b).

³¹ Section 4(2)(j).

- 7.12. The geotechnical assessment report from Engineer 1 that accompanied the building consent stated the Type 4 is designed to be a 2m high anchored wall, and the Type 5 is designed as a 2.2m high non-anchored cantilever wall.
- 7.13. The as-built plans from Engineer 2 indicate that the Type 4 wall is up to 1.9m high, and the Type 5 wall is between 1.95m to 2.03m high with a maximum retained height of 2.0m.
- 7.14. The expert engaged by the Ministry stated that each of the Type 4 and 5 retaining walls are to “retain [a] height of approximately 2.0m, for a combined retained height of approximately 4m”. The expert noted that the retained height of the wall varied from 0.45m up to a maximum of 2.06m for the Type 4 wall, and from 1.97m up to a maximum of 2.07m for the Type 5 wall.
- 7.15. In consideration of the as-built information currently available, the varying heights of the Type 4 and 5 retaining walls are substantially in accordance with the building consent plans. This takes into consideration the relatively minor variances in the figures, the means and accuracy by which these were obtained (either by tape measurement or survey recordings), and the tolerances that may be expected when constructing these types of structures.

The slope of the ground and the existing retaining wall

- 7.16. The agent’s letter dated 29 September 2020 also stated, “The actual site slope profile taking into account the existing low old landscaping retaining wall, has not been taken into consideration in the building consent”.
- 7.17. The existing low-level timber retaining wall is located on 15 and 17 Hartwell Place, and is between 0.84m to 1m north of the new Type 4 retaining wall.
- 7.18. The original building consent plans from Engineer 1, and the as-built plans from Engineer 2, do not include a reference to the existing low-level timber retaining wall.
- 7.19. However, the geotechnical assessment report from Engineer 1 that accompanied the building consent did refer to the “existing retaining wall” and this was included in the slope stability analyses. The same report also states, “the slope height is approximately 8m [high] with a typical slope angle between 27 and 45 degrees”.
- 7.20. The original building consent plans do indicate a slope of between 25 to 50 degrees below the Type 4 retaining wall (refer to figure 2). Although the as-built plans did not indicate an angle for the slope they do note that the approximate ground level varies.
- 7.21. The expert noted that based on the results of the surveyor’s assessment, the angle of the slope below the existing retaining wall varied between 24.2 degrees to 33.8 degrees.

- 7.22. The expert confirmed “the angle adopted for the retaining wall design is based on the 1m high existing retaining wall being ignored”. The expert also noted “the existing retaining wall is no longer providing support for the above slope and is now limited to providing support to the narrow width of soil between it and the Type 4 retaining wall”.
- 7.23. The expert referred to the apparent deterioration of the existing retaining wall and stated it “had limited stability and structural integrity when Building Consent 300162 was granted, and has not lost any further stability or structural integrity as a result of the construction of the new Type 4 and 5 retaining walls”.
- 7.24. From the evidence available, it is clear that the site slope profile and existing retaining wall directly north of the new Type 4 wall were taken into consideration as part of the design associated with the building consent.

Protection of other property – Clause B1 Structure

- 7.25. The agent considered that “in respect of protecting...other property”, Clauses B1.1, B1.2, B1.3.1, B1.3.3 and B1.3.4 were applicable. The points of contention raised by the agent were the height of the new retaining walls, the slope of the ground to the north, and the effect of the as-built construction on the existing retaining wall located on the applicant’s property.
- 7.26. The agent summarised the issue as “the [new] retaining wall...has a high probability of structural failure that would cause risk to [the] other property below...” and “proper account has not been taken of the physical conditions that affect the stability of the retaining wall”.
- 7.27. A Chartered Professional Engineer (Engineer 1), who specialises in structural and civil engineering, created the original design for the Type 4 and 5 retaining walls and provided a Producer Statement – Design (PS1), plans and specifications to support the design.
- 7.28. During the construction phase on site, another Chartered Professional Engineer (Engineer 2) conducted several inspections (see Appendix C, table 2) and authorised a series of changes in the design as the works progressed (see Appendix D, table 3). This resulted in a set of as-built plans and structural calculations drafted by Engineer 2, along with another PS1. Engineer 1 peer reviewed these plans and provided a Producer Statement – Design Review (PS2) along with supporting documentation.
- 7.29. The authority granted and issued both the original building consent and the amendment to it based on the as-built construction information.
- 7.30. The expert stated, “despite the discrepancies in the analysis undertaken by the retaining wall designer..., the Type 4 and Type 5 retaining wall as built, are

considered to meet the requirements of Clause B1 [Structure] of the New Zealand Building Code” (see paragraph 5.4.9).

- 7.31. The expert considered the requirements of Clauses B1.1 (c), B1.2, B1.3.1, B1.3.3 (b), (d), (e), (f) and B1.3.4, and in all instances, concluded that compliance with the Building Code has been achieved for the purposes of protecting other property (see paragraph 0).
- 7.32. The expert also considered Clause B1.3.6(b) and did not indicate any matters of non-compliance.
- 7.33. I have already reached the conclusion that the height of the Type 4 and 5 retaining walls are substantially in accordance with the building consent, and that the design has considered the slope of the ground and existing retaining wall on the applicant’s property.
- 7.34. Therefore, in consideration of the information available, I am of the view that the Type 4 and 5 retaining walls do comply with the aspects of Clause B1 of the Building Code that have the purpose of protecting other property.

Protection of other property – Clause F5 Construction and Demolition Hazards

- 7.35. In their letter dated 31 March 2021, the agent stated “...the safeguard of other property from damage is also provided for under [Building Code clause] F5” and “compliance has not been demonstrated...in the building consent, for the construction and/or demolition that is a likely eventuality, to achieve a complying building structure”.
- 7.36. The geotechnical assessment report from Engineer 1, that formed part of the original building consent, included reference to “safety in design” (see paragraph 2.7). This specifically addressed issues of the type of machinery to be used by the builder to minimise any slope instability during construction.
- 7.37. The builder and Engineer 2 also provided several photographs of the site during the construction phase. As per the expert’s observations (see paragraph 5.5.7), it appeared that the vegetation downslope was untouched by the earthworks and that the condition of the existing retaining wall was similar to prior to construction (with less loading force).
- 7.38. I have received no information indicating that suitable construction methods have not been used to avoid the likelihood of tools or materials falling onto places where people might be present, or of causing damage to other property, or that any such event has occurred.
- 7.39. However, I note that the building work is incomplete. As such, appropriate measures still need to be implemented and followed by the owners and the

builder to avoid any construction hazards that may cause damage to other property, until the building work is completed.

7.40. Therefore, in consideration of the information currently available, I am of the view that the construction of the Type 4 and 5 retaining walls 'to date' do comply with the aspects of Clause F5 of the Building Code that have the purpose of protecting other property from damage.

8. Decision

8.1. In accordance with section 188(1)(b) of the Building Act 2004, I determine:

- the design and construction of the Type 4 and 5 retaining walls associated with building consent 300162 comply with Clause B1 of the Building Code, and
- the construction of the Type 4 and 5 retaining walls associated with building consent 300162 to date complies with Clause F5 of the Building Code

in as far as those clauses relate to the protection of other property.

Signed for and on behalf of the Chief Executive of the Ministry of Business, Innovation and Employment on 7 March 2022.

Katie Gordon

National Manager Building Resolution

APPENDIX A

The Building Code

Clause B1 – Structure

Objective

B1.1 The objective of this provision is to:

- (a) Safeguard people from injury caused by structural failure,
....
- (c) Protect other property from physical damage caused by structural failure.

Functional Requirement

B1.2 Buildings, building elements and sitework shall withstand the combination of loads that they are likely to experience during construction or alteration and throughout their lives.

Performance

B1.3.1 Buildings, building elements and sitework shall have a low probability of rupturing, becoming unstable, losing equilibrium, or collapsing during construction or alteration and throughout their lives.

B1.3.3 Account shall be taken of all physical conditions likely to affect the stability of buildings, building elements and sitework, including:

- ...
(b) Imposed gravity loads arising from use,
...
- (d) Earth pressure,
- (e) Water and other liquids,
- (f) Earthquake,
...

B1.3.4 Due allowance shall be made for:

- (a) The consequences of failure.
- (b) The intended use of the building,
- (c) Effects of uncertainties resulting from construction activities, or the sequence in which construction activities occur,
- (d) Variation in the properties of materials and the characteristics of the site, and
- (e) Accuracy limitations inherent in the methods used to predict the stability of buildings.

B1.3.6 Sitework, where necessary, shall be carried out to:

- (a) Provide stability for construction on the site, and
- (b) Avoid the likelihood of damage to other property.

Clause F5 – Construction and demolition hazards**Objective**

F5.1 The objective of this provision is to safeguard people from injury, and other property from damage, caused by construction or demolition site hazards

Functional Requirement

F5.2 Construction and demolition on buildings shall be performed in a manner that avoids the likelihood of:

- (b) Objects falling onto people on or off the site,
- (c) Objects falling on property off the site,
- (c) Other hazards arising on site affecting people off the site and other property...

Performance

F5.3.1 Suitable construction methods shall be used to avoid the likelihood of tools or materials falling onto places where people might be present.

APPENDIX B

Table 1: Design and as-built data for Type 4 and 5 retaining walls

Building elements	Type 4 retaining wall	Type 5 retaining wall
Total length of wall	Design: 17.1m ³² As-built: 14.025m	Design: 17.2m As-built: 11.45m
Height of wall above ground level	Design: Varies up to a maximum of 1.95m As-built: 0m to 1.9m	Design: Varies up to a maximum of 1.95m As-built: 1.95m to 2.03m
Diameter of timber poles	Design: 275mm As-built: 275mm to 300mm	Design: 225mm As-built: 225mm
Spacing between poles	Design: 1.2m As-built: 1.05m to 1.45m	Design: 1.2m As-built: 0.9m to 1.35m
Total pole length	Design: 9.0m As-built: 5.0m to 5.3m ³³	Design: 6.0m As-built: 5.8m
Timber treatment ³⁴ of poles	H5 As-built: No change	H5 As-built: No change
Poles are anchored (using specialist ground anchors)	Yes As-built: No change	No
Ground anchors (drilled and bolted into each timber pole of the Type 4 retaining wall)	Yes Design: 25mm diameter, grade 500E hot dip galvanised, 8m long As-built: 20mm diameter, grade 500E hot dip galvanised, between 8m to 10.7m long	No
Maximum retained height of ground supported by the wall	Design: 4.0m As-built: 1.9m	Design: 2.2m As-built: 2.0m
Minimum pole embedment into the ground	5.0m As-built: No change	3.8m As-built: No change
Concrete encasement diameter	Design: 600mm As-built: No change	Design: 450mm As-built: 500mm to 550mm

³² Total (design) length of the walls scaled from the original building consent plans 007 Revision 4 dated 6 July 2020 and 008 Revision 3 dated 6 July 2020.

³³ I note the pole lengths of 5.0m-5.3m on plan 003 of 8 (Rev. D), don't match the longer pole lengths indicated on plan 007 of 8 (Rev. D) which indicates lengths of between 5.0m to approximately 7.2m.

³⁴ NZS 3640:2003 *Chemical Preservation of Round and Sawn Timber*, Table 3.1 – Hazard classification.

Rake of pole ³⁵	0 degrees As-built: No change	Less than 5 degrees As-built: No change
Timber Lagging boards between poles	Design: 2 or 3 layers of 190mm high x 45mm thick As-built: 2 or 3 layers of 150mm high x 45mm thick	Design: 1 layer of 190mm high x 45mm thick As-built: 1 layer of 150mm high x 45mm thick
Timber treatment for lagging boards	H4 As-built: No change	H4 As-built: No change

The text in red is data taken from the original building consent plans by Engineer 1.

The text in blue is data from the as-built plans prepared by Engineer 2.

The **bold** text highlights the differences between the two sets of data.

³⁵ The “rake” refers to the angle the poles are set into the ground relative to the vertical plane (ie 0 degrees is directly vertical).

APPENDIX C

Table 2: Summary of site observations by peer review engineer

Date of inspection	Observations
13 Aug 2020	<p>Site clear and prepared for drilling; silt fence located on boundary.</p> <p>Poles sizes, timber treatment, and locations checked.</p> <p>Lagging size 150mm high x 50mm thick (H4 timber treatment)</p> <p>Nails correct size (3.2mm diameter, 100mm long galvanized)</p>
14 Aug 2020	<p>Holes drilled to correct diameter (600 – 700mm), correct depth (5.0m – 5.4m), correct inclination, and installed correctly.</p> <p>Noted “slight change to centres due to obstructions (1 hole) second pole from corner on lower wall type 4”.</p>
18 Aug 2020	<p>Concrete used was 25MPa, and poured to the correct level.</p> <p>Poles were are 1.2m centres, except two pole at 1.4m centres, and one pole at 1.5m centre.</p> <p>Inclination of pole was at 2 degrees.</p> <p>First layers of lagging placed correctly including overlap with poles.</p>
21 Aug 2020	<p>Excavation made for 20mm diameter galvanized ground anchors. Location and angle of anchors (between 10 to 15 degrees) agreed with Contractor.</p> <p>Poles complete for Type 4 wall.</p>
27 Aug 2020	<p>Ground anchors installed; testing and certification to be confirmed.</p> <p>Sub-soil drains installed.</p>
2 Sept 2020	<p>Site compaction (shear vane testing), backfill material to walls</p>
7 Sept 2020	<p>Ground anchors installed, connected with washers and nuts</p> <p>Ground anchors “tested and passed”; greater than 60kN anchor achieved when 45kN was the target. Creep tests passed.</p> <p>Remaining lagging installed, “height 50mm less than design”.</p> <p>Filter cloth, drainage, and backfill in place for Type 4 wall.</p> <p><u>Type 5 wall</u></p> <p>Pole size and timber treatment checked.</p> <p>Poles correctly marked out, between 1.m to 1.25m spacings.</p> <p>Holes drilled correctly, between 500mm to 550mm diameter.</p> <p>Holes drilled to a depth of 3.7m.</p>
18 Sept 2020	<p>25MPa concrete poured to correct level.</p> <p>Poles set at 4 to 5 degree lean.</p> <p>Lagging placed for Type 5 wall.</p> <p>Filter cloth and sub-soil drainage installed.</p>

	<p>Included description of Type 4 tied to existing “old timber half round wall”, and 90 degree tie-in between walls.</p> <p>Confirmed location of Type 4 wall posts “are well within 67 Waratah boundary by 300mm” using a string line.</p>
25 Sept 2020	Fill paced behind walls. Temporary fence installed.
6 May 2021	<p>Ground levels restored to pre-construction levels.</p> <p>Soil has been grass seeded.</p> <p>For wall Type 5 the posts are 2.0m or less in height.</p> <p>For wall Type 4 the heigh of the posts is 1.9m at the front and 2.0m on the back.</p> <p>New bolts and nails installed as per design.</p>

APPENDIX D

Table 3: Summary of “changes” authorised by peer review engineer

Date	Changes
12 Aug 2020	Confirmation of testing of ground anchor specification and testing schedule.
13 Aug 2020	Type 4 wall, 2 fewer poles used, down to 12 (from 14).
19 Aug 2020	Change to ground anchor locations (2 anchors at 0.5m from the top of the post instead of 1.0m as per the original design). Last two poles have no anchor as they have a retained height of less than 0.5m to tie into the existing wall.
21 Aug 2020	Ground anchor changed to larger size ³⁶ , allows for greater capacity
21 Aug 2020	Angle of ground anchor lowered to 10 degrees, trajectory in plan view as per drawings. Depth of anchor plate is still below critical depth for full capacity (to be confirmed in pull out test).
21 Aug 2020	20mm diameter anchor bar instead of 25mm. Checked for degradation from corrosion. Minimum bar diameter allowed is 19.8mm; 20mm greater, therefore okay.
24 Aug 2020	Confirmation of anchor testing.
02 Sept 2020	Backfilling. A second fill type further back behind walls.
03 Sept 2020	Bar corrosion through wall. Change from steel trumpet sleeve to a protruding PVC.
07 Sept 2020 ³⁷	For wall Type 5, 4 fewer poles installed, down to 10 in total (from 14).
17 Sept 2020	Detail of corner connection, squared rather than angled, provides a stronger connection. Loads applied to lagging are reduced by the geometry of the other walls and soil arching.
18 Sept 2020	Tie into existing walls; this was not designed for. All connections have appropriate spans until the restraining timber has been placed and lagging has 3 span minimum across other posts before spanning to connection. Type 4 corner tie in. Type 5 to Type 1 wall tie-in.
18 Oct 2020	Manufacturer to confirm anchor plates.

³⁶ Note the engineer stated, “anchor type changed to larger size” when it was actually reduced from “20mm anchor bar instead of 25m[m]”.

³⁷ The “change” schedule stated 2018, but the preceding and following dates are all 2020.