



Determination 2021/007

Regarding the code compliance of a frameless glass balustrade on a house at 6 Leading Light Lane, Governors Bay, Rāpaki

Summary

This determination considers the code compliance of a frameless cantilevered glass balustrade. The balustrade panels comprise a laminate of two toughened-glass panes with a plastic interlayer. Concerns about compliance of the balustrade were raised when the interlayer did not prevent a panel from collapsing when the glass was broken.

1. The matter to be determined

- 1.1 This is a determination under Part 3 Subpart 1 of the Building Act 2004 (“the Act”) made under due authorisation by me, Katie Gordon, National Manager Determinations, 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:
 - M and T Tutko, who are the owners of the property where the balustrade that is the subject of this determination is located (“the applicants”)
 - Christchurch City Council as the building consent authority involved with the building work (“the authority”).
- 1.3 I have also included Glassforce Ltd, the company that installed the balustrade (“the installer”), as a person with an interest in the determination. The installer is acting through its solicitor as its agent.
- 1.4 For ease of reference, I will refer to the applicants, the installer and the authority collectively as the parties. The determination also refers to the company that supplied the glass to the installer (“the supplier”).
- 1.5 The determination concerns a frameless glass balustrade, installed by the installer at the applicants’ property as a minor variation to a building consent. One pane in the balustrade has since failed, and the applicants are concerned that the balustrade does not comply with the Building Code.

¹ The Building Act and Building Code are available at www.legislation.govt.nz. The Building Code is contained in Schedule 1 of the Building Regulations 1992. Information about the Building Act and Building Code is available at www.building.govt.nz, as well as past determinations, compliance documents and guidance issued by the Ministry.

- 1.6 The matter to be determined² is whether the frameless glass balustrade, as installed, complied with Clauses B1.3.1, B1.3.4(a), B2.3.1, F2.3.3(a), and F4.3.4(c) and (d) of the Building Code. I have not considered the compliance of any other clause of the Building Code relevant to the balustrade’s design and construction. This determination does not concern the compliance of the balustrade after the breakage, but does take into account how the panel behaved after that event insofar as it provides information to assess the balustrade, as installed, against the performance criteria of the relevant clauses of the Building Code.
- 1.7 I have considered the parties’ submissions, the report of the independent expert (“the expert”) commissioned by the Ministry to advise on the issue, and the other evidence in this matter.
- 1.8 In making my decision, I have taken into account the purposes and principles of the Act. In particular with regard to the performance of the balustrade:

3 Purposes

This Act has the following purposes:

(a) to provide for the regulation of building work, the establishment of a licensing regime for building practitioners, and the setting of performance standards for buildings to ensure that—

(i) people who use buildings can do so safely and without endangering their health;
...

4 Principles to be applied in performing functions or duties, or exercising powers, under this Act

2) In achieving the purpose of this Act, a person to whom this section applies must take into account the following principles that are relevant to the performance of functions or duties imposed, or the exercise of powers conferred, on that person by this Act:

(a) when dealing with any matter relating to 1 or more household units,—

(i) the role that household units play in the lives of the people who use them, and the importance of—

(A) the building code as it relates to household units; and

(B) the need to ensure that household units comply with the building code: ...

2. The building work and background

- 2.1 The applicants’ property (Lot 20 DP 372956) is a two-storey house on a sloping site in a very high wind zone. The house has a small deck on its lower level, with a timber balustrade, and a larger deck on its upper level, with a frameless glass balustrade.
- 2.2 The house was constructed in 2017, pursuant to a building consent issued on 12 August 2016. During construction the frameless glass balustrade that is the subject of this determination (“the balustrade”) was installed in place of the balustrade that was specified in the consent.
- 2.3 The balustrade is made up of laminate panels comprising two panes of 6mm thick toughened safety glass and a 0.76mm ionoplast³ interlayer. The panels are mounted in a U-shaped aluminium channel. The channel is face-fixed to the vertical face of the deck’s edge, so that the top of the channel is approximately 115mm below the top

² Under section 177(1)(a) of the Act.

³ Ionoplast is a semi-crystalline polymer that is commonly used as an interlayer in laminated glass

- of the deck. The laminate panels are then held in place in the channel using a proprietary clamping system, with the clamp fixings spaced at about 400mm centres; there is no inter-linking top rail to the top edge of the glass panels.
- 2.4 I understand the glass panels and clamping system used were supplied by a company (“the supplier”) that is not the manufacturer of the panels.
- 2.5 The installer has advised that the balustrade’s design and specifications were supplied by a company of ‘chartered structural engineers’, which the installer engaged for this purpose. I have not seen a copy of these specifications.
- 2.6 The installer’s terms and conditions attached to its quotation state that:
- Whilst some systems are fully compliant, [the installer] is primarily an installation company. Most systems are accredited and certified compliant by other parties, although [the installer] does certify the installation of these products.
- 2.7 On 3 February 2017, the installer provided a Producer Statement - Design (“PS1”) for the applicant’s balustrade. The PS1 certified that:
- The glass as specified and shown on the plans is compliant to the New Zealand Standard NZS 4223 Part 3 June 2016. ^[4]
 The glass marking verifies compliance to NZS 2208.
 The structural safety glass is processed in New Zealand
- 2.8 The PS1 also stated that the installer is a registered member of the Window and Glass Association of New Zealand, the PS1 would only be valid if the installer carried out the installation work for the balustrade itself, and that the installer would monitor the project to ensure ‘legal compliance is achieved’. (For ease of reference, I will refer to this producer statement as “Producer Statement A”).
- 2.9 Attached to the installer’s Producer Statement A, were copies of plans relating to the balustrade. The plans show a face-fixed frameless glass balustrade, with a height of 1m above the finished floor level of the deck, which was to be ‘supplied and designed’ by the installer, in accordance with the PS1. The plans do not provide any further detail of the laminate panels or fixing system to be used.
- 2.10 In January or February 2017, the applicants applied to the authority for an amendment to the building consent to substitute the installer’s balustrade for the timber balustrade shown on the consented plans. Attached to the application was the installer’s Producer Statement A with its attached plans, and three further producer statements. These producer statements were issued by third parties and certified the code compliance of different aspects of the balustrade’s construction.
- PS1 issued by the structural engineering designers to the supplier on 9 February 2015 (“Producer Statement B”). This PS1 certifies a glass balustrade system that uses 12mm monolithic toughened glass mounted in an aluminium channel – the latter being face-fixed to the supporting structure. The certification was for compliance with Clause B1, in accordance with B1/VM1. This PS1 is further referenced in Producer Statement C (see below).
 - PS1 issued by the design consultants to the installer on 30 May 2016 (“Producer Statement C”). This PS1 certifies the use of 12mm laminated toughened safety glass as a replacement for 12mm monolithic toughened glass. The certification was for compliance with Clause B1 in accordance with B1/AS1. (Note, that there is no explicit statement as to whether this PS1 certifies compliance against B1/AS1 Amendment 12, or Amendment 13 which

⁴ New Zealand Standard NZS 4223.3:2016 *Glazing in buildings - Part 3: Human impact safety requirements*

came into effect the day after the date on the statement). Attachments to this PS1 included:

- a drawing specifying a ‘12mm laminated toughened safety glass made up of: - 2 of 6 mm sheets toughened safety glass, - 1 of 0.76 mm ionoplast stiff interlayer, - laminated as per [the third-party glass manufacturer’s] specification to comply with NZS4223:2016 22.4.3 c)’
 - a separate commentary that stated ‘6mm Laminated Toughened Safety Glass with a 0.76 mm Ionoplast interlayer can be used in place of 12 mm toughened safety glass, for this load scenario’.
 - PS1 issued by the glass testing reviewers and base fixing designers to the supplier on 16 August 2016 (“Producer Statement D”). This PS1 certifies the testing of a 12mm toughened monolithic glass balustrade system (including the aluminium face-fix mounting that has been used at 6 Leading Light Lane) for barrier loads and wind loads. The certification was for compliance with Clauses B1, B2, F2, F4, in accordance with B1/VM1. Drawings of the balustrade system specified that it was to have an ‘interlinking top rail with an edge support system’, although an annotation to the drawing stated that, as an alternative, a ‘minimum 16 mm thick Laminated Glass (8mm+interlayer+8mm) without interlinking top rail’ could be used, in accordance with NZS 4223.3:2016.
- 2.11 The authority refused the amendment on 7 February 2017; in its submission the authority advised that while details of the glass balustrade were received there was no accompanying application form for an amendment and accordingly the authority did not proceed with its ‘technical acceptance check’ for the proposed amendment. The authority did not receive a further application.
- 2.12 The balustrade was nonetheless installed by the installer on 6 May 2017. The applicants believe that the substitution was subsequently dealt with as a minor variation to the building consent agreed to onsite by an officer of the authority at the final inspection, although there is no documentation to confirm this.
- 2.13 The authority issued a code compliance certificate for the building work on 14 September 2017.

The break and investigation

- 2.14 On May 2019, one pane of the two laminated panes of glass in one panel of the balustrade broke suddenly. The panel remained in place.
- 2.15 The applicants’ insurance company arranged for a glazing company (“the insurer’s glazier”) to replace the broken panel. The insurer’s glazier raised concerns about the code compliance of the balustrade, specifically they considered the interlayer in the panels was insufficiently stiff, and contacted the Windows and Glass Association of New Zealand (“WGANZ”).
- 2.16 WGANZ investigated the matter and appointed a third party glass manufacturer and installer to review the consent information, conduct a site visit, and carry out wind load calculations for the applicants’ property (“WGANZ’s reviewer”). The reviewer measured the glass panels and reported⁵ that:
- overall panel thickness was 12.4mm to 12.5mm

⁵ As recorded in a report by WGANZ dated 19 August 2019

- thickness of an unbroken glass pane was approximately 5.9mm
 - height from the top of clamp to the top of glass was 1165mm
 - panel length was 2453mm
 - fragment count of the broken pane was approximately 54, indicating toughened glass.
- 2.17 WGANZ’s reviewer concluded that the balustrade panels were made of 12mm toughened laminated glass panes with ‘what resembles a stiff interlayer’ although it was not possible to establish ‘the exact interlayer type’ used. The reviewer noted that, if the glass type specified in the PS1 (Producer Statement C) had been used, this would have been compliant at the time of installation. However, the height of the installed laminated panels (1165mm to 1175mm) was above the maximum noted in the PS1 (1115mm).
- 2.18 The insurer’s glazier continued to have concerns about the balustrade’s compliance and carried out an on-site test to determine how the laminated panel would perform if both panes of safety glass were broken. The test, captured on two videos, involved the insurer’s glazier breaking the second pane of glass, then pushing the panel with his fingertips. The test was not conducted in accordance with any official testing standards. The videos show that after the second pane of glass was broken and pushed, the panel immediately folded over on itself and fell to the ground. The panel appears to have snapped or sheared off along the top of the aluminium channel holding it, leaving the bottom part of the panel in the channel. The panel on the ground was then torn by hand by the insurer’s glazier to demonstrate that portions could be torn off it.
- 2.19 WGANZ viewed the two videos and on 23 July 2019, emailed the insurer’s glazier, stating that in its opinion the applicants’ balustrade was ‘non-compliant’.
- 2.20 This communication was passed on to the applicants, and on 29 July 2019 the applicants emailed the installer asking it to replace the balustrade.
- 2.21 The installer arranged for a laminated panel of the same composition as that used in the applicants’ balustrade to be impact tested using a swing bag test. The test was carried out on 12 August 2019 by a third-party glass balustrade installation company (“the third-party installer”). The installer also arranged for a company of consulting engineers (“the installer’s engineers”) to independently review the third-party installer’s test and confirm that the test had been undertaken in accordance with NZS 4223.3:2016 paragraph 22.4.3 note (4). The results of the test and the engineer’s commentary were provided to WGANZ.
- 2.22 The third-party installer provided a video of the test, and photos showing the dimensions of the laminated panel tested and the test apparatus set up. The photos show that the panel tested was 1500mm wide and 1275mm high. In an email, the third-party installer confirmed that the swing bag had been released from a height of 1450mm ‘that being 1200mm the top of the cuboid channel’, but did not provide any written specifications of the test apparatus used. The panel did not break during the test.
- 2.23 On 19 August 2019, WGANZ produced a report on its investigations. The report noted that the height of the panels was more than the maximum in the Producer Statement PS1 Design and it was unclear what type of interlayer was used. The report concluded that compliance had not been demonstrated and suggested that the installer carry out further tests. An addendum to the report refers to the swing bag

- testing carried out by the installer on 12 August 2019, but noted that as the glass panel did not break during the test, this left them ‘without a result’ with regard to establishing compliance by way of NZS 4223.3:2016 paragraph 22.4.3(a) and (b).
- 2.24 The installer responded in a letter dated 23 August 2019, disagreeing with the findings in the WGANZ report. The installer considered that the swing bag test had been carried out in accordance with NZS 4223.3:2016 paragraph 22.4.3 (note 4) and was the correct test to use to determine if the panels complied with paragraph 22.4.3(c). As the panel had remained intact during the test, this demonstrated compliance.
- 2.25 On 29 August 2019 and 6 September 2019, the applicants emailed the installer asking it to either confirm that the balustrade that had been installed on their property was the same as the one specified in the PS1 or replace the balustrade with a code compliant one and provide a new PS1.
- 2.26 The installer’s solicitors replied to the applicants in a letter dated 13 September 2019. The letter set out the installer’s views on the compliance of the balustrade and I have included the main points of this letter here as it summarises the installer’s opinions on matters that are relevant to this determination.
- The testing by the insurer’s glazier was not done in accordance with paragraph 22.4.3 (note 4) of NZS 4223.3:2016; the testing should not have been carried out when the glass was already broken, and was not independent.
 - The producer statements relied on by the applicants were provided to the authority by the installer solely ‘for the specific purpose of procuring a building permit to install the glass balustrades’ and were never intended as a warranty as to the actual composition of the balustrades. The purpose of the documents was to enable the authority ‘to assess the design and structural engineering aspects of the installation’ to ensure it was code compliant.
 - The installer was only engaged to install the balustrades at the applicants’ property. The installer engaged chartered engineers to produce design specifications for the project, and based on these the installer ordered the balustrades from the supplier.
 - The supplier provided the installer with Producer Statement D for the glass balustrade, which showed that they were ‘compliant for installation at [the applicants’ property] in accordance with the specifications and design from the chartered engineers engaged by [the installer]’.
 - Producer Statements A (the installer’s), B and C, were ‘used for general design consultancy and structural engineering design’, whereas Producer Statement D ‘specifically covers the glass balustrades, with a defined focus on glass testing review / design for base fitting and structural design’.
 - Producer Statement D is ‘the main document for matters relating to the structure of glass balustrades’, and replaces Producer Statement C (which specifies the ionoplast interlayer). This is confirmed, with respect to the balustrade system installed at the applicants’ property, in a letter dated 6 September 2019 from the company that provided Producer Statement C.
 - The installer cannot comment on the reason for the damage to the balustrade, as it only installed it. The installer has asked the supplier for ‘confirmation of

the glass composition of the glass balustrade’, but the supplier has declined to comment.

- The installer thinks that the ‘structural interlayer’ used in the applicants’ balustrade panels is an ethylene vinyl acetate (EVA) interlayer, but is ‘not in a position to confirm this’ without independent testing on the in-situ balustrade.
- 2.27 The applicants’ replied to the installer’s solicitor’s letter on 18 September 2019, stating that they did not accept the information provided, and that the glass panels used were non-compliant as they did not contain a stiff interlayer as required by NZS 4223.3:2016, but instead had a “soft interlayer”.
- 2.28 In September 2019, the installer arranged for the installer’s engineers to review testing it had previously carried out on a frameless glass balustrade system, which incorporated 1100mm high glass panels, to see if the panel height could be increased to 1170mm and remain compliant.
- 2.29 The engineer provided a report dated 30 September 2019, in which it concluded that the ‘13.52mm glass balustrade with cuboid fixing details provided by the installer can also be used for the locations where the maximum panel height is less than 1170mm’ provided the original design constraints still applied.
- 2.30 The installer sent a copy of this report to the applicants on 11 October 2019. However, the applicants did not consider it relevant as it related to a different thickness of glass panel than that used in their balustrade.
- 2.31 The installer’s solicitor sent the applicants a further letter dated 29 October 2019. The letter stated the balustrade had been independently certified as fully compliant, and that it had supplied ‘independent, specialist reports and testing’ to verify this.
- 2.32 The installer’s solicitor also sent WGANZ a letter dated 29 October 2019. The letter set out the installer’s perspective on the inquiry and review undertaken by WGANZ, and advised that the installer was withdrawing from that process.
- 2.33 The applicants applied for a determination as to whether the balustrade complied with the Building Code at the time it was installed, and the application was accepted by the Ministry on 13 December 2019.

3. The initial submissions

The applicants

- 3.1 The applicants made a submission with their application for a determination. The submission sets out the applicants’ concerns that the balustrade is non-compliant and would not prevent a person falling from the balcony if both panes in one of the laminated panels broke. In particular, they are concerned that the panels do not appear to have ‘a stiff interlayer between the two panes as specified in the engineer’s designs’, and this has been confirmed by the WGANZ investigation. The testing done by the insurer’s glazier, although not in accordance with any standards, shows how the laminated panels perform in the case of dual breakage of the panes, and show that the panels are clearly unable to prevent themselves collapsing, which is not compliant with the Building Code.
- 3.2 With their submission, the applicants enclosed:
- an outline of events

- documentation relating to the quotation, specification and installation of the balustrade
- correspondence between the applicants, the installer and WGANZ
- videos of the insurer's glazier's test
- WGANZ's report
- the installer's engineer's report
- photographs of the broken panel.

The authority

- 3.3 The authority made a submission dated 19 December 2019, in which it explained the circumstances surrounding the applicants' application for an amendment to the building consent and the authority's refusal of the application. With its submission, the authority supplied copies of:
- the supporting information about the balustrade supplied by the applicants with the application for an amendment to the building consent
 - the authority's correspondence with the applicants, including the application for an amendment form sent to the applicants.

The installer

- 3.4 The installer made a submission dated 12 February 2020 in response to the application for a determination. In its submission the installer advised that it was unable to confirm the composition of the panels because they had been supplied by another company. The installer had 'relied on the Producer Statements supplied by [the supplier] and the chartered structural engineers that were engaged by [the installer] for the said installation'. There was 'no reason' for the installer not to rely on these documents. The installer has asked the supplier to confirm the composition of the glass balustrades, but the supplier does not want to comment for 'commercial sensitivity and intellectual property' reasons.
- 3.5 With respect to compliance, the installer submitted that the swing bag test carried out by the third party installer (see paragraphs 2.21 and 2.22) on 12 August 2019, and the installer's engineer's testing and report of 30 September 2019 (see paragraphs 2.28 and 2.29) met the testing requirements in NZS 4223.3:2016 and confirmed that the balustrade complied.
- 3.6 The installer is concerned at the applicants' refusal to accept this specialist evidence, when, in the installer's opinion, the applicants had not provided any specialist advice to support their own claim of non-compliance. The testing by the insurer's glazier did not comply with appropriate testing standards and should not have been carried out on already damaged glass. The installer also did not accept WGANZ's decision in its report of 24 October 2019, as this decision was made without reference to any of the evidence provided by the installer.
- 3.7 With its submission, the installer enclosed:
- documentation relating to the third party installer's swing bag test
 - WGANZ's report
 - the installer's engineer's report

- correspondence between the installers, the applicants and WGANZ.

4. The expert's report

- 4.1 As stated in paragraph 1.7, I engaged an independent expert to assist me. The expert is a principal research engineer with a multi-disciplinary consultancy, and has a thorough understanding of the expected performance of glass balustrades and the building controls legislation as it applies to such balustrades. The expert provided a report dated 22 April 2020, which was circulated to the parties on 23 April 2020.
- 4.2 The expert reviewed the documentation supplied by the parties, and the relevant building code requirements, standards, acceptable solutions and verification methods that applied to the applicants' balustrade.
- 4.3 The expert also reviewed the various compliance documentation that had been supplied for the balustrade, and the testing that had subsequently been undertaken in respect of it.
- 4.4 The expert considered that the compliance clauses that applied were B1 Structure, B2 Durability, F2 Hazardous building materials and F4 Safety from falling, but noted that the parties' submissions had focussed on Clause B1.
- 4.5 With respect to Clause B1, the expert considered it reasonable to assume that Acceptable Solution B1/AS1 Amendment 13 had been used as the basis for establishing the compliance of the balustrade. B1/AS1 Amendment 13 required the balustrade to comply with the requirements in NZS 4223.3:2016, in particular paragraph 22.4.3(c).
- 4.6 With respect to wind loads and barrier loads, the standard requires AS/NZS 1170 and B1/VM1 to be complied with, and the expert considered that adequate evidence of this had been provided through producer statements B, C and D.
- 4.7 With respect to post-fracture collapse, paragraph 22.4.3(c) of NZS 4223 requires frameless glass barriers, without an interlinking rail, to be made of heat strengthened or toughened laminated safety glass with a stiff interlayer that prevents collapse in the event of dual pane breakage. The swing bag test described in note 4 to paragraph 22.4.3(c) 'helps interpret what is an acceptable test load for a broken laminated glass balustrade'.
- 4.8 With respect to the swing bag test undertaken by the third-party glazier on the installer's behalf, this did not demonstrate compliance with paragraph 22.4.3(c), because the glass panes in the panel were not broken. The expert rejected the installer's argument that the test in note 4 was intended to be carried out on an unbroken panel, as this would not 'test the post-fracture performance of a balustrade with both panes broken, which circumvents the purpose of the [paragraph 22.4.3]'.
- 4.9 The expert then considered the on-site test undertaken by the insurer's glazier and considered that, even taking into account 'the variation in force that could be applied through someone's fingertips' and the variation that could occur in how glass panels could fracture and collapse, it was 'very difficult to conclude that the balustrade would have a low probability of collapse when both glass panes are fractured'.
- 4.10 The expert concluded that:
- On this basis, the balustrade design does not have an acceptably low probability of collapse in post-fracture situations and in doing so, does not take adequate account of the consequences of failure, and so fails to comply with B1.3.1 and B1.3.4(a).

Because the barrier was non-compliant and had collapsed it also did not comply with Clause F4.

4.11 Responses to the expert's report

- 4.11.1 The applicants responded to the expert's report in an email dated 28 April 2020. The email clarified the order in which the panes of glass had broken, and the testing carried out on-site at the applicants' property.
- 4.11.2 The installer responded to the expert's report in an email dated 15 May 2020. The installer considered that the swing bag test conducted by the third-party installer established that 'the balustrade will sustain the impact' specified in the standard. The installer noted that the expert's report focussed on the post-fracture compliance of the balustrade, but this created an issue because no 'independent testing' had been done to establish post-fracture compliance, and the on-site testing conducted by the insurer's glazier was not 'an acceptable and credible test'.
- 4.11.3 The installer considered the expert should not have concluded that the existence of 'an "alleged" non-compliant panel' would make the whole balustrade non-compliant, when the reason that the panel broke had never been established and no independent testing of the panel had occurred.

5. The draft determination and submissions received in response

- 5.1 The draft determination was issued to the parties for comment on 18 June 2020.
- 5.2 The authority and applicants accepted the draft without comment in responses received on 29 June and 1 July 2020 respectively. The authority noted some typographical errors.
- 5.3 The installer did not accept the draft determination and through its solicitors provided a further submission dated 2 July 2020. The submission made substantial commentary on the history of NZS 4223.3:2016, its testing regimes and amendments, and made the following main additional points that are relevant to this determination.
- Both the Ministry expert's report and the draft determination focus on the post-fracture compliance of the balustrade.
 - B1/AS1 Amendment 15 includes a testing requirement for the post-fracture performance of frameless glass balustrades, while B1/AS1 Amendment 13 does not. The appropriate testing regime to use to establish the compliance of frameless laminated glass balustrades under B1/AS1 Amendment 13 and NZS 4223.3:2016 paragraph 22.4.3 remains unclear.
 - The installer believes that the glass to be used in the swing bag test in note 4 of paragraph 22:4.3 of NZS 4223.3:2016 should be undamaged, while the draft determination agrees with the Ministry's expert that the test is to be conducted on panels where both panes of glass are already fractured.
 - The reason why one of the panels was damaged was never established, but the installer considers this is important because it will confirm if it is a compliance issue.
 - If the core issue is the composition of the glass panels, then 'the testing regime and the parameters of the testing' have to be very clear and easily replicated.

The installer requested the determination provide clear guidance on the testing regime and its parameters for compliance under B1/AS1 Amendment 13 and NZS 4223.3:2016, for the guidance of the glass industry.

- The issue of the post-fracture compliance of the balustrade was not raised during the consenting process, and the installer relies on the producer statements issued by its third party suppliers.

6. Discussion

6.1 General

6.1.1 The applicants have applied for a determination about whether the frameless glass balustrade installed at their property complies with the Building Code.

6.1.2 There are a number of clauses of the Building Code that apply to the performance of the balustrade. However, the particular clauses of the Building Code that are relevant to the disputed matter are:

- B1 Structure (B1.3.1, B1.3.3 and B1.3.4(a))
- B2 Durability (B2.3.1 (b))
- F2 Hazardous building materials F2.3.3(a)
- F4 Safety from falling (F4.3.4(c) and (d)).

6.1.3 The main aspect of compliance that is in dispute between the applicants and the installer is Clause B1 Structure which is considered in paragraph 6.4.3 below.

6.2 Clause B2 Durability

6.2.1 Clause B2.3.1 requires the balustrade to be sufficiently durable that it continues to satisfy the other functional requirements of the Building Code for the duration of its design life.

6.2.2 However, the fact that one panel of the applicants' balustrade has collapsed does not mean that compliance with this clause has not been achieved. This is because the cause of failure has not been established. There are potential reasons for failure that would not be considered a failure to meet the performance criteria in respect of durability.

6.3 Clause F2 Hazardous building materials

6.3.1 Clause F2.3.3 requires the glass balustrade, which people are likely to come into contact with, to resist a reasonably foreseeable impact without breaking (F2.3.3(b)), or if broken on impact, break in a way which is unlikely to cause injury (F2.3.3(a)).

6.3.2 The installer has asserted (in Producer Statement A) that the glass panes used in the laminate panels have been certified to comply with AS/NZS 2208:1996 Safety glazing materials in buildings. This Standard, requires glass to break into many small "dice" (as compared to larger shards of glass).

6.3.3 I have not seen any evidence of this certification (for example, a Standard mark on the glass panes). However, the video of the insurer's glazier's on-site testing confirms that this is how the glass in one of panels behaved when broken. This behaviour, together with the installer's assertion of certification, and the presence of

an interlayer in the laminated panel, is sufficient evidence for me to conclude that the balustrade complies with Clause F2.3.3(a).

6.4 Clause F4 Safety from falling

6.4.1 Clause F4 requires that the balustrade has certain characteristics that help prevent people falling from the deck.

6.4.2 The relevant performance requirements from Clause F4 that apply in this case are:

F4.3.4 Barriers shall:

- (a) be continuous and extend for the full extent of the hazard,
- (b) ...
- (c) be constructed with adequate rigidity,
- (d) be of adequate strength to withstand the foreseeable impact of people and, where appropriate, the static pressure of people pressing against them,
- (e) ...

6.4.3 Whether the balustrade has adequate rigidity (F4.3.4(c)) and adequate strength (F4.3.4(d)) are questions that arise from its structural performance under Clause B1, and in this case the assessment for compliance of the balustrade as installed can draw on evidence that became apparent after the panes had been broken.

6.5 Clause B1 Structure

6.5.1 The majority of the parties' submissions concern the balustrade's compliance with Clause B1 Structure. The applicants consider that the balustrade does not comply with Clause B1 because the laminated glass panels are insufficiently rigid and will collapse when both panes are broken, as demonstrated by the insurer's glazier's onsite test. The installers consider that the panels do comply, and that this has been established by the swing bag test conducted by the third-party glazier, in accordance with NZS 4223.3:2016 paragraph 22.4.3(c) note 4.

6.5.2 Clause B1 seeks (among other things) to safeguard people from injury caused by structural failure (Clause B1.1), which requires buildings and building elements to withstand the combination of loads that they are likely to experience during construction or alteration and throughout their lives (Clause B1.2).

6.5.3 The relevant structural performance requirements for the purpose of this determination are in Clause B1.3.1, which requires a low probability of collapse; Clause B1.3.3, which specifies the physical conditions that need to be taken into account; and Clause B1.3.4(a), which requires due allowance for the consequences of failure:

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* or 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:

- (a) self-weight,
- (b) imposed gravity loads arising from use,...
- (h) wind,...
- (j) impact,

B1.3.4 Due allowance shall be made for:

(a) the consequences of failure, ...

- 6.5.4 Whether the laminated glass panels used in the applicants' balustrade have a low probability of becoming unstable or collapsing, and whether due allowance has been made for the consequences of failure, are central issues in this determination.
- 6.5.5 What is meant by 'low probability' and 'consequences' are not explained or defined in either the Act or the Building Code. However, guidance on what they mean in practice, and how compliance with Clause B1 can be achieved, can be found in the verification method (B1/VM1) and Acceptable Solution (B1/AS1) for Clause B1. I note here that although verification methods and Acceptable Solutions provide pathways for demonstrating compliance, they are not the only means of doing so, and it is open to the parties to use alternative methods, if desired.

Verification Method B1/VM1

- 6.5.6 Verification method B1/VM1 specifies the wind loads and barrier loads that glass balustrade designs must resist. These loads are a good benchmark for demonstrating the compliance of glass balustrades with Clause B1 (in particular Clause B1.3.3), but they are not a complete solution for glass balustrades for this clause, as no material standards for glass are cited in B1/VM1.
- 6.5.7 For the applicants' balustrade, the installer has sought to establish the structural capacity of the balustrade through physical testing, with the test results being documented in the various producer statements provided. Of particular relevance are:
- Producer Statement D, which certifies the compliance of a balustrade system that used the same aluminium face-fix mounting as that used on the applicants' balustrade and 12mm toughened monolithic glass, for barrier loads and wind loads: certification was for compliance with Clause B1 in accordance with B1/VM1
 - Producer Statement C, which certifies the use of 12mm laminated toughened safety glass as a replacement for 12mm monolithic toughened glass: certification was for compliance with Clause B1, in accordance with B1/AS1.

Acceptable Solution B1/AS1

- 6.5.8 Another way that compliance with Clause B1 can be established is through compliance with Acceptable Solution B1/AS1. The Ministry also issued section 175 guidance on barrier design, including cantilevered glass barriers, in March 2012⁶.
- 6.5.9 The applicants' balustrade was specified and installed in early 2017, at which point Acceptable Solution B1/AS1 (1st edition) was subject to a number of amendments⁷. The building work on the applicants' balustrade occurred in the transition period for these amendments.
- 6.5.10 The main difference between the amendments to B1/AS1, for the purpose of this determination, is with respect to the post-fracture performance requirements for frameless glass barriers.

⁶ Guidance on Barrier Design (published March 2012) available at: www.building.govt.nz/building-code-compliance/b-stability/b1-structure/guidance-on-barrier-design/. Section 4.1.4.3(d) of the guidance says if a cantilevered glass barrier has no interlinking rails "the barrier is designed using heat strengthened or toughened laminated safety glass with an interlayer that prevents collapse in the case of dual-pane breakage..."

⁷ Amendment 13 effective from 1 June 2016 until 30 May 2017; Amendment 14 effective from 4 November 2016 until 30 May 2017; Amendment 15 effective from 1 January 2017 until 30 June 2018.

- B1/AS1 Amendment 13 and 14 cites NZS 4223.3:2016 as part of the glazing solution, meaning compliance with NZS 4223.3:2016 is required to comply with the Acceptable Solution.
- B1/AS1 Amendment 15 also cites NZS 4223.3:2016, but includes specific loading requirements for the post-fracture performance of frameless laminated glass barriers. These specific loadings replace those set out in paragraph 22.4.3(c) of NZS 4223.3:2016.

6.5.11 It is not clear which version of B1/AS1 was being used to demonstrate compliance of the balustrade at the point that it was specified and installed. However, given the dates of the various producer statements it is reasonable to assume that it was B1/AS1 Amendment 13. The installer's own Producer Statement A, and some of the other producer statements it supplied certify the balustrade's compliance with NZS 4223.3:2016 and make no mention of the specific loading requirements in B1/AS1 Amendment 15. In addition, the installer has subsequently used the swing-bag test mentioned in note 4 to paragraph 22.4.3 of that Standard, as a means of demonstrating compliance with paragraph 22.4.3(c). This test would have been redundant had Amendment 15 been the version of B1/AS1 that was being followed.

6.5.12 The relevant passage of B1/AS1 Amendment 13 in this case is paragraph 7.3.3, which reads:

Glass balustrades and fences that are fully framed, unframed or partly framed or structural shall comply with section 22 of NZS 4223.3: 2016.

6.5.13 As stated above, this means that in order to comply by way of the Acceptable Solution B1/AS1 the balustrade must conform to section 22 of NZS 4223.3: 2016, which covers glass barriers (balustrades, fences and screens). Paragraph 22.1 of that Standard specifies that glass used in balustrades shall be toughened or laminated safety glass. The other relevant paragraph for the purpose of this determination is 22.4.3:

22.4.3 Structural glass barriers

...

All structural glass barriers safeguarding a fall of 1000 mm or more shall have interlinking rails (see note 1) unless one or more of the following applies:

...

(c) The barrier has heat-strengthened or toughened laminated safety glass with a stiff interlayer that prevents collapse in the case of dual pane breakage (see note 4).

6.5.14 Paragraph 22.4.3 is followed by an explanatory note, which includes note 4 about a test that may be used in relation to paragraph 22.4.3(c).

(4) The barrier may be designed and tested to remain intact after a 46 kg swing bag test released from a drop height of 1200 mm above the centre of the barrier section and impacting the middle of the barrier. The test aligns with AS/NZS 2208 and guidance provided in ASTM E2353.

The note is informative and has been included to provide additional information and guidance for users.

Compliance of the applicant's balustrade

6.5.15 Turning now to the applicants' balustrade, I accept that the installer has demonstrated the balustrade's compliance with Clause B1.3.3 with respect to the barrier, wind and impact loads that it has been designed to withstand. Although none of the producer

statements supplied by the installer relate directly to the configuration of the barrier, as it was installed, I am satisfied that collectively they provide adequate evidence of the barrier's compliance with the loading requirements in B1/VM1.

- 6.5.16 However, matters are not so clear with respect to the barrier's post-fracture performance, and hence its compliance with Clauses B1.3.1 and B1.3.4. The requirement for glass barriers to meet certain standards of post-fracture performance was introduced into B1/AS1 with Amendment 13. As set out above, this required glass balustrades to comply with section 22 of NZS 4223.3:2016, which in turn required them to incorporate "heat-strengthened or toughened laminated safety glass with a stiff interlayer that prevents collapse in the case of dual pane breakage".
- 6.5.17 The applicants' barrier incorporates an interlayer, although the installer is unable to advise its exact composition. What is at issue is the adequacy of this interlayer to prevent collapse in the event that both panes of glass in a panel are broken.
- 6.5.18 None of the producer statements supplied by the installer touch on the issue of post-fracture performance. The installer submits that the swing bag test carried out at its request by the third-party installer demonstrates compliance with NZS 4223.3:2016 paragraph 22.4.3(c). The installer submits that as the test was carried out in accordance with note 4 to that paragraph of the Standard, and the laminated panel did not break, this shows that the panel complies.
- 6.5.19 I do not agree that this is the case. Note 4 is included in the Standard as guidance, and it does not state whether the test is to be carried out on a broken or unbroken panel. The actual standard that must be met is set out in paragraph 22.4.3(c) of the Standard, which is clear that what is being gauged is the performance of a laminated panel after both panes of glass in it have been broken. Both the Ministry's expert and WGANZ have expressed the opinion that a test on an unbroken panel cannot be used to demonstrate the performance of a panel in a dual pane breakage situation; and I concur with this position.
- 6.5.20 The installer has reasserted in its submissions on the draft determination that the test in note 4 is to be carried out on an unbroken panel. With respect, I do not agree that this can be the case. An unbroken panel cannot be used to test how that panel will perform once broken. The test is not whether the panel will break when exposed to the force exerted by the swing bag (which is what the installer appears to be asserting), but how it will perform when exposed to that force after it is already broken. It is the post-fracture performance that is at issue.
- 6.5.21 Paragraph 22.4.3(c) of NZS 4223.3:2016 does not define the conditions under which a broken glass panel must not collapse. In particular, it does not specify the degree of force or loading that the panel must be able to withstand before it does collapse. Note 4 can be used to help interpret what is an acceptable test load for a broken laminated glass balustrade, which is described as a 46 kg swing bag, released from a height of 1200 mm, impacting the middle of the glass panel. This is a relatively severe impact and from the evidence presented in this determination I consider it highly likely that the applicants' barrier would collapse if such a load was applied to one of its panels when the glass was already broken.
- 6.5.22 No independent testing under laboratory conditions, by those experienced in testing these systems in accordance with the Standard, has been carried out on a broken panel of the type used in the applicants' balustrade. The installer disputes the veracity of the testing that was carried out by the insurer's glazier. However, even though this testing was not formally conducted it was recorded and in my opinion

confirms that the applicants' balustrade does not meet the test in paragraph 22.4.3(c) of the Standard. In the video of the test, the installer's glazier is shown to briefly push the broken glass panel with his fingertips. Even allowing for potential differences in the force that a person could exert in this way, I consider it highly unlikely that it would come anywhere near to the loadings applied via the swing bag test described in note 4 of the Standard, or to those that could be expected if a person stumbled and fell against the broken panel.

6.5.23 Taking into account the discussion above, I conclude that the balustrade as installed does not comply with Clauses B1.3.1 and B1.3.4(a) in respect of its performance in post-fracture situations.

6.6 Other matters

6.6.1 The installer has raised a few other matters in its submissions, including in its submissions on the draft determination that I consider require a response.

6.6.2 In its submissions, the installer has asserted that as the reason that the panel broke in the first place has never been established, it cannot be assessed whether it complies. While it is undoubtedly of interest to the installer why the panel broke, this does not impact on its performance after it has broken. It is this performance that is of interest for establishing compliance with Clauses B1.3.1 and B1.3.4 via paragraph 22.4.3(c) of the Standard.

6.6.3 In its submissions on the draft determination, the installer also asserted that if the 'core issue' is the composition of the glass, then the determination should provide guidance on the testing regime to be used to establish compliance with B1/AS1 and NZS4223.3:2016. In response, I note that:

- the matter being determined is not the composition of the glass panels, but the performance of the balustrade itself
- what is required to be demonstrated is compliance with Clause B1 and compliance with Clause F4, not compliance by means of the Acceptable Solution and standard; while these provide a means of establishing compliance, they are not the only means
- B1/AS1 Amendment 13 and NZS4223.3:2016 do provide guidance on the testing to be used to establish the post-fracture compliance of frameless glass balustrades, and this determination clarifies that this testing is to be carried out on panels that are already fractured. For balustrades installed at a later date, B1/AS1 Amendment 15 includes specific loading requirements for the post-fracture performance of frameless laminated glass barriers.

6.7 Conclusion

6.7.1 As noted above, there is insufficient information on the cause of the failure of the glass panel to reach a conclusion on compliance with Clause B2.3.1.

6.7.2 The behaviour of the glass panel after the panes were broken, together with the installer's assertion of certification and the presence of an interlayer in the laminated panel, is sufficient evidence for me to conclude that the balustrade complies with Clause F2.3.3(a).

6.7.3 In my opinion, the applicants' balustrade as installed does not have an acceptably low probability of collapse in post-fracture situations and in doing so, does not take

adequate account of the consequences of failure. Accordingly it fails to comply with Clauses B1.3.1 and B1.3.4(a).

- 6.7.4 If the barrier collapses because it does not comply with Clause B1, then the barrier cannot be said to be constructed with adequate rigidity or adequate strength and so does not comply with Clauses F4.3.4(c) and (d).

7. The decision

- 7.1 In accordance with section 188 of the Building Act 2004 I hereby determine that the frameless glass balustrade as installed complied with Building Code Clause F2.3.3(a) but did not comply with Clauses B1.3.1, B1.3.4(a) and F4.3.4 (c) and (d).

Signed for and on behalf of the Chief Executive of the Ministry of Business, Innovation and Employment on 16 April 2021.

Katie Gordon
National Manager Determinations