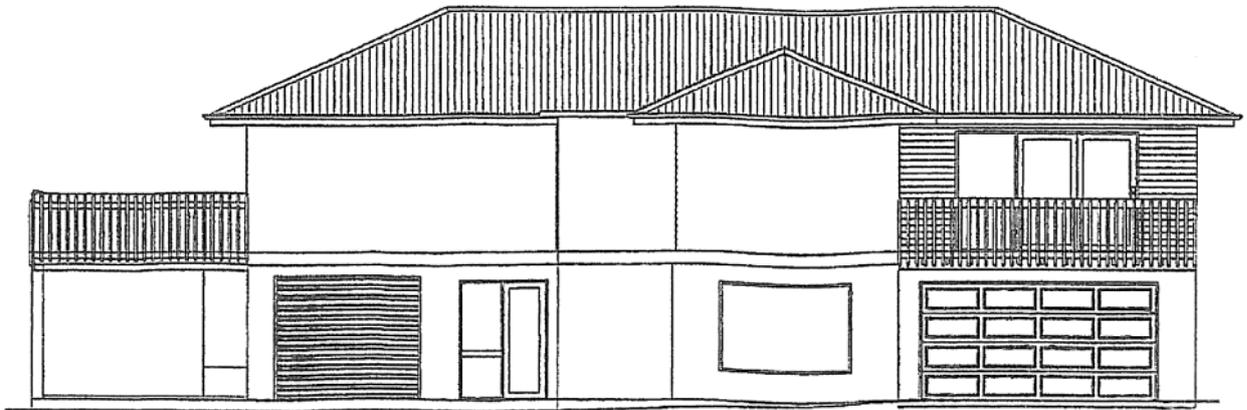




Determination 2010/029

The issuing of a notice to fix and the code-compliance of roof trusses for a house addition located at 80 Atkinson Road, Titirangi, Auckland



1. The matter to be determined

1.1 This is a determination under Part 3 Subpart 1 of the Building Act 2004¹ (“the Act”) made under due authorisation by me, John Gardiner, Manager Determinations, Department of Building and Housing (“the Department”), for and on behalf of the Chief Executive of the Department.

1.2 The parties to this determination are:

- Mr I Fleming, the owner of the house (“the applicant”), who is acting through the building products supplier
- the Waitakere City Council (“the authority”) carrying out its duties and functions as a territorial authority and a building consent authority.

¹ The Building Act, Building Code, Compliance documents, past determinations and guidance documents issued by the Department are all available at www.dbh.govt.nz or by contacting the Department on 0800 242 243.

- 1.3 This determination arises from the decision of the authority to issue a notice to fix because it was not satisfied that the grading and treatment of trusses used in construction of the house addition complied with certain clauses² of the Building Code (Schedule 1, Building Regulations 1992).
- 1.4 I take the view that the matters for determination³ are whether:
- the roof trusses used for the additions to a house comply with clause B1“Structure” of the Building Code
 - the decision of the authority to issue a notice to fix for the additions to the house was correct.
- 1.5 The following terms have been used in this determination to describe the organisations involved in the supply of the materials and the manufacture of the roof trusses in question:
- the supplier of the non load-bearing (“NLB”) timbers (“the timber processor”)
 - the supplier of the roof truss design software (“the software designer”)
 - the manufacturer and supplier of the trusses (“the truss manufacturer”)
 - a firm supplying building products (“the building products supplier”)
- 1.6 In making my decision, I have considered the submissions of the parties, the report from an officer of the Department (“the officer”), and the other evidence in this matter.

2. The building work

- 2.1 The building work in question concerns the roof trusses of an addition to form a two-storey house. The house is situated in a low wind zone for the purposes of NZS 3604⁴.
- 2.2 The trusses are generally located at 900 centres to form the upper roof and they support a metal roof covering fixed to purlins. The trusses are fixed to the top plates of the walls. According to the information that I have received, the trusses are constructed with re-graded NLB timbers (described by the timber processor as being timber with stiffness below the threshold for grading as MSG8⁵). The truss layout for the addition is shown in Figure 1.

² In this determination, unless otherwise stated, references to sections are to sections of the Act and references to clauses are to clauses of the Building Code.

³ In terms of section 177(a) and 177(iv)

⁴ New Zealand Standard NZS 3604:1999 Timber Framed Buildings

⁵ Machine Stress Grading

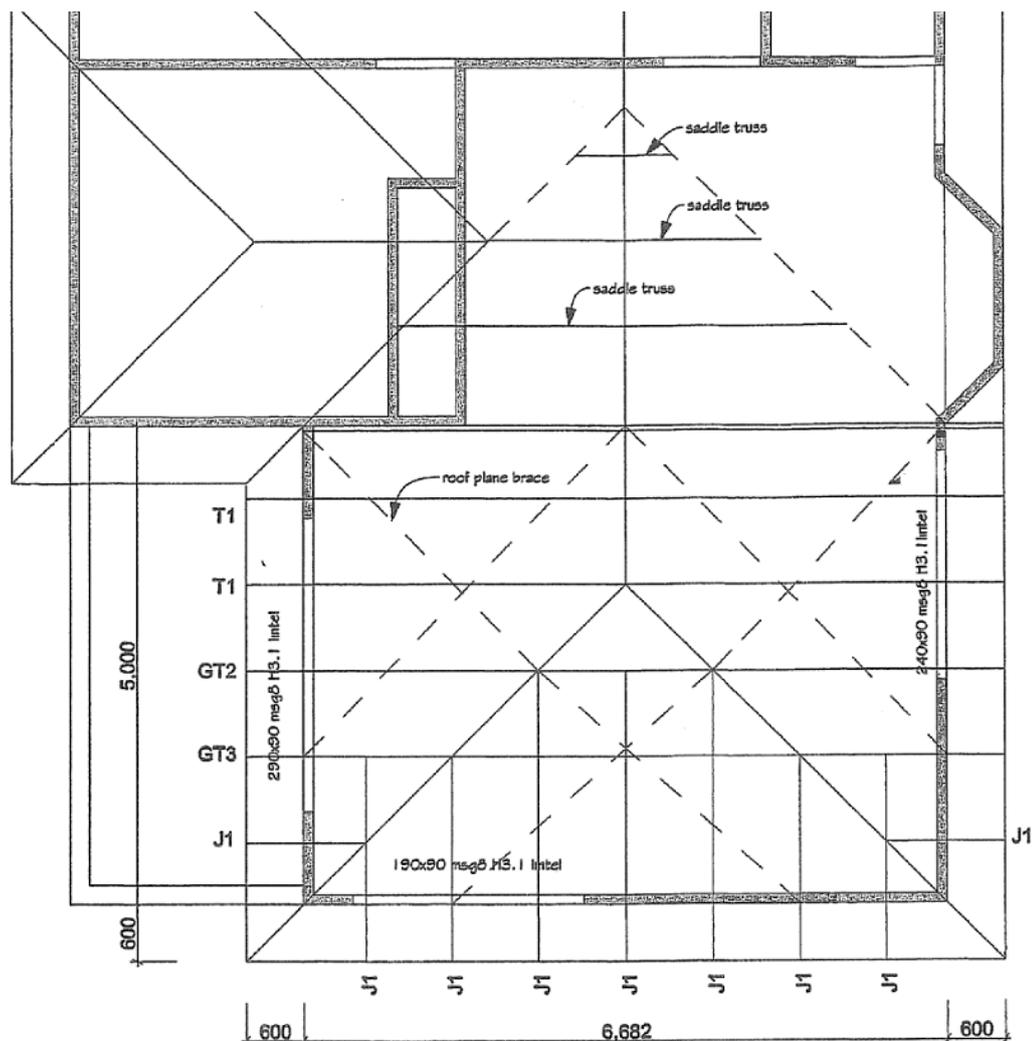


Figure 1: the truss layout for the addition

2.3 The specification of work for the proposed alterations and additions notes the following:

SELECTIONS

33 CARPENTRY

Floor and roof framing; MSG8 H3.1

CARPENTRY

33.1 TIMBER FRAMING GENERALLY

Species, grade and level of treatment to NZS 3602, tables 1 to 3 Requirements for wood-based building components ..., and moisture content to NZS, table 4 Allowable moisture content... Grading to NZS 3631. Mechanical stress grading acceptable as an alternative to visual grading.

33.3 TIMBER FRAMING DRY, TREATED

Species, grade and level of treatment to NZS 3602, tables 1 to 3 Requirements for wood-based building components ..., and moisture content to NZS, table 4 Allowable moisture content... Grading to NZS 3631. Either mechanical stress graded to AS/NZS 1748, or visual grading to NZS 3631.

33.11 EXECUTION GENERALLY

To NZS 3604 except as varied in this specification.

3. Background

- 3.1 The authority issued a building consent (No COM-2008-140), which I have not seen, for the house in 2008. Following an inspection during construction, the authority issued a notice to fix dated 18 December 2008.
- 3.2 The particulars of contravention or non-compliance on the notice to fix stated:
- Dwelling being constructed under Building Consent COM-2008-140 does not comply with the objective and functional requirements of Clause B1 Structure of the New Zealand Building Code.
- To remedy the contravention or non-compliance you must:
1. Replace the trusses of the dwelling with suitably graded/treated timber in accordance with Clause B1 (structure) of the New Zealand Building Code.
- Or
2. Lodge an amendment to your building consent application, confirming that all affected structural elements comply with the requirements for No 1 trusses, as per NZ3604, together with a certificate from a suitably qualified person establishing that the timber complies with No 1 trusses, in accordance with NZ3604...
- Or
3. Apply to the Department of Building and Housing for Determination on this matter.
- 3.3 The timber processor wrote to the authority on 3 December 2008, providing information on the re-graded NLB timber that it supplies. The processor noted that, unless re-graded NLB timber is verified, there can be no guarantee as to its structural properties.
- 3.4 Prior to this, the building products supplier commissioned a Crown research institute (“the research institute”) to report on the properties of regraded NLB timbers.
- 3.5 The report from the research institute, dated 10 December 2008, noted that it had tested 100 randomly selected lengths of market re-graded 90mm x 45mm of the timber processor’s NLB timber for bending strength and stiffness in accordance with NZS 4063⁶. From the information that I have received, I believe that the samples were provided during the November to December 2008 period.
- 3.6 In summary, the test results showed that the 90 x 45mm material:
- achieved the bending strength for the MSG8 and Visual Stress Grading VSG8⁷ grades
 - failed to achieve the bending stiffness (the modulus of elasticity) for MSG8 and VSG8 grades, however, it did achieve the bending stiffness for MSG6 and No 1 Framing grades

⁶ AS/NZS 4063:1992 Timber - Stress-graded - In-grade strength and stiffness evaluation

⁷ Visual stress grading

- the 90 x 45mm material failed to achieve the lower bound bending stiffness for MSG8 and VSG8 grades. However, it did achieve the lower bound bending stiffness for MSG6 and No 1 Framing grades.

The report was accompanied by detailed information regarding the tests carried out.

3.7 In a letter to the building products supplier dated 18 December 2008, the research institute also noted that density and content samples were cut from 33 pieces and these showed:

- the average test density was 456kg/m³
- the average oven-dry density was 398kg/m³
- the average moisture content test was 14.7%.

The letter also noted that, if the bending strength of MSG graded structural timber is satisfied, then this indicates that the other strength properties should also be satisfied.

3.8 A consultant was engaged by the building products supplier to investigate the modelling (computer simulation) of the bending stiffness of re-graded timber used by the building products supplier. The consultant's report is dated January 2009.

3.9 The simulations analysed the local modulus of elasticity measurements of 6000 lengths of timber processed by a stress grader. The results and trends reinforced the results of the testing undertaken by the research institute. Modelling shows that removing below stiffness material from lengths of NLB timber increases the stiffness properties of the timber. However, the increase in stiffness is not to the level of the MSG8 timber.

3.10 The modelling highlighted the importance of sample size to establish characteristic values. The report concluded that in order to make an adequate assessment of the population characteristics, the sample should be random and taken over a long period of time, as was the case with the research institute's sample testing.

3.11 From the computer simulations, the following values were established:

- the characteristic stiffness value of the MSG8 timber.
- the characteristic stiffness value of NLB timber.
- the characteristic stiffness value of the re-graded NLB timber when selected, and lengths of 1650, 2400, and 3900mm were analysed.

These estimates were at the 75% confidence level.

3.12 The research institute was requested by the building products supplier to recalculate the previously obtained data as two separate modules - material that passed the timber processor's visual inspection and material that did not. In a report dated 2 February 2009, the research institute produced three tables as follows:

Table 1: Bending Strength and Stiffness properties for the sorted 90x45 material

Data	Characteristic Bending Stiffness, GPa	Characteristic Bending Strength, MPa	Number of Pieces	Average Test Density kg/m ³	Average Nominal Density kg/m ³
All Data	6.57	15.12	99	457 (33 pieces)	398 (33 pieces)
Pieces passing CHH visual inspection	6.58	15.90	73	445 (25 pieces)	388 (25 pieces)
Pieces failing CHH visual inspection	6.05	10.31	26*	441 (8 pieces)	384 (8 pieces)

* AS/NZS4063:1992 requires a minimum of 30 pieces to calculate bending strength

Table 2: Characteristic stresses for machine graded timber NZS3603 A4

Moisture Content – Dry (m/c = 16%) Characteristic Stresses						
Species	Grade	Bending Strength MPa	Compression Strength MPa	Tension Strength MPa	Bending Stiffness GPa	Lower bound Bending Stiffness GPa
Radiata Pine & Douglas Fir	MSG 15	41.0	35.0	23.0	15.2	11.5
	MSG 12	28.0	25.0	14.0	12.0	9.0
	MSG 10	20.0	20.0	8.0	10.0	7.5
	MSG 8	14.0	18.0	6.0	8.0	5.4
	MSG 6	10.0	16.0	4.0	6.0	4.0

Table 3: Characteristic stresses for visually graded timber NZS3603 A4

1. Moisture Content – Dry (m/c = 16%) Characteristic Stresses					
Radiata pine and Douglas Fir	Bending Strength MPa	Compression Strength MPa	Tension Strength MPa	Bending Stiffness GPa	Lower bound Bending Stiffness GPa
VSG10	20.0	20.0	8.0	10.0	6.7
VSG8	14.0	18.0	6.0	8.0	5.4
No 1 Framing	10.0	16.0	4.0	6.0	4.0
2. Moisture Content – Green (m/c = 25%)					
G8	11.7	12.0	4.0	6.5	4.4
No 1 Framing	7.5	11.0	3.0	4.8	3.2

3.13 In an undated letter, the software designer noted that their roof design software had been used by the truss manufacturer to design the trusses for the house addition. The software designer had reviewed the truss design using their software and the research institute's nominated structural properties for re-graded NLB timber. The letter noted:

The as-built re-graded [timber processor's] "NLB" timber and the associated structural properties nominated by [the research institute] satisfied the strength requirements for the chord and web members.

Although the timber stiffness is lower, all inter-panel and overall truss deflections have been checked with the reduced stiffness and found to be within the normal design limits.

The fixings used in the original design are adequate, based on reasonable grounds in which the average density of the re-graded [timber processor's] "NLB" being similar to the average density used for MSG8.

The software designer stated that the letter did 'not condone the use of the specific re-graded NLB timber in frames and trusses, but served as a means to 'establish a resolution for structures built using this product prior to December 2008'.

- 3.14 The authority emailed the applicant on 16 January 2009, stating that the authority would accept the grade of timber used in the trusses, providing that it was visually graded by a person who is certified to verify timber grades. It was also noted that the grading cannot reflect that the timber in the trusses is less than No1 Framing Grade.
- 3.15 The application for a determination was received by the Department on 13 February 2009.

4. Submissions in response to the application

- 4.1 The applicant noted that the primary matter to be determined was whether the installed roof trusses complied with the Building Code 'using the developed methodology'.
- 4.2 The applicant forwarded copies of the:
- plans and specifications
 - truss construction details
 - reports from the research organisation
 - notice to fix
 - confidential information memorandum on re-graded NLB timber
 - correspondence with the authority
 - correspondence between the various organisations
 - information regarding the re-graded NLB timber supplied by the timber processor.
- 4.3 The authority provided a submission to the Department dated 15 April 2009. The authority stated that the notice to fix was issued because the use of re-graded NLB timber was not verified as complying with clause B1. The issue for determination was the methodology to be used to determine code-compliance given the lack of regulation in this area. The authority listed its concerns with the proposed methodology and noted that the potential risks arising from the use of re-graded NLB timber must be adequately considered and rectified. The authority was of the view that currently it would require a producer statement from either:
- (i) a chartered structural engineer (or similar) following a site inspection, or
 - (ii) the truss or frame manufacturer addressing those issues respectively identified in the Guidance Document⁸ issued by the Department.

⁸ Non load-bearing timber issues – guidance information for building consent authorities (December 2008)

5. The officer's report

5.1 General

- 5.1.1 As described in paragraph 1.6, an officer of the Department, who is a Chartered Professional Engineer, provided me with an initial report that gave an assessment of the matters subject to this determination and which was forwarded to the parties. Feedback was received from the building products supplier and internal advisors to the Department. A final peer reviewed report dated 23 June 2009 was issued with the draft determination.
- 5.1.2 The report described the various trusses and their associated construction and summarised the testing procedures undertaken on behalf of the building products supplier. It was noted that the modelling carried out was limited and confined to the one dataset only. This dataset represented the specific population of re-graded NLB timber that was applicable to the manufacturer of the trusses in question. The report emphasised that the term "non load-bearing timber" is used for convenience to indicate a different grading and does not imply that the timber is unsuitable for structural purposes.
- 5.1.3 The officer accepted the timber processor's contention that, if the density and moisture content of the NLB timber is similar to that of 'dry' MSG8, then fixing performance with the re-graded NLB timber will be similar to that of fixing performance in MSG8.

5.2 The trusses in question

- 5.2.1 The officer made a site visit to the house before the ceilings had been installed, and took measurements and photographs of the trusses and roof framing.
- 5.2.2 The officer noted that in general deflection due to creep is of far more concern than an increase in immediate deflection between MSG8 and MSG6 timber due to lower stiffness properties. In this case, the deflection of the trusses in question was found to be very small. The design information showed 1.2mm truss deflections at the bottom chord node points under dead load. This was considered insignificant when compared with the suggested serviceability limit state criteria of 13mm to 18mm for this free span load case. The officer noted that:
- significantly less than the distortion limit in the transverse direction associated with a stiff adjacent double truss (3.5 mm). The trusses were installed dry however this distortion limit (of 3.5 mm) would still not be reached even if the moisture content of the truss timbers were more than 25% for 12 months or more.
- 5.2.3 The report noted that the main issue is whether the reduced stiffness implied by the properties of the re-graded NLB timber will affect its compliance. This was assessed by taking into account Clause 7.3 of AS/NZS 1170.0⁹, relating to serviceability limit states, which is cited in Verification Method B1/VM1. Compliance with this standard would constitute code-compliance.

⁹ AS/NZS 1170.0: 2002 Structural Design Actions

- Based on this criterion, the maximum free span truss deflection allowed, and the corresponding design deflection based on the re-graded NLB timber properties, are:
 - (i) 13 to 22mm under dead load only, depending on the condition being guarded against. (Design deflection – 1.3mm and 2.2mm respectively).
 - (ii) 32mm under dead load plus part live or wind uplift load. Accordingly compliance was achieved. (Design deflection – 1.8mm).
 - (iii) 32mm under dead load plus downward wind load (4.3mm).
- Checks on the deflection of the individual chord members with the concentrated live loads specified in AS/NZS 1170.0 at mid-span, indicated that the deflection was at the suggested upper limit of Table C1 of the Standard.
- Deflection of the truss top chord overhang at the eaves is critical but it is normal industry practice to assume some load spread by crossing members such as fascia boards. Documentation received from the software designer indicates that the deflection between node points was set by the truss manufacturer at 7mm.
- A check of the transverse distortion between the short span double truss and the first full span truss was done. The calculated deflection of this first adjacent full span truss under dead load based on the re-graded NLB properties is 1.3 mm and the deflection relative to the adjacent double truss, because of the small shorter span double truss deflection and the load sharing due to the crossing ceiling battens and purlins, is not likely to exceed 1mm.

5.2.4 The report concluded that the trusses in question met the strength requirements of NZS 3603¹⁰ and the serviceability requirements of AS/NZS 1170.0. As both these documents are cited in B1/VM1 as a means of compliance, the trusses were considered to be code-compliant. However, it was appreciated that the level of confidence associated with the properties determined for the re-graded NLB timber is less than that for MSG8. Properties of the re-graded NLB timber have been determined with a confidence of 75% whereas the timber processor's MSG8 is produced with a confidence level between 90 and 95%.

5.3 The responses of the parties to the officer's report

5.3.1 The building products supplier noted that the deflection limits in truss design software comply with AS/NZS 1170.0. Table C1. The building products supplier also noted that it is industry practice to assume that moisture content is 18% or less when the ceiling is installed and that an average long term creep deflection is 1.5 times initial dead load deflection. This requires that trusses which are exposed to wetting during construction dry out once the roof sheathing is installed and prior to the ceiling load being added.

¹⁰ NZS 3603:1993 Timber Structures Standard

- 5.3.2 The software designer has advised that a camber of 1.5 times the dead load deflection is applied to trusses. This means that when the dead load deflection occurs theoretically there is no long term displacement below a threshold “level line” due to dead load taking account of creep.

5.4 The application of this methodology to other situations

- 5.4.1 The report also commented on the application of the design verification methodology in the subject house to other situations. This methodology is set out in paragraphs 5.4.2 to 5.4.10.
- 5.4.2 For other houses where trusses and wall frames have been manufactured using this timber, compliance could be determined using NZS 3603, the suggested serviceability limit state criteria in AS/NZS 1170.0, and the re-graded NLB properties. However, the checks must be done using the specific truss or wall frame dimensions, member sizes and loading applicable to each particular situation. It cannot be assumed that the properties that proved adequate in the current determination will prove adequate in other situations.
- 5.4.3 Careful consideration must be applied to determine whether the trusses in any particular application are, or have been, subject to high moisture content prior to loading, and what effect, if any, the change in moisture content within the timber might have on the calculated long-term deflections. It must be noted that the observations made herein apply to all timber trusses, irrespective of the grading of timber used, and not just where NLB has been used.
- 5.4.4 An assessment of other building consent applications for compliance using this re-graded NLB timber should at least include the appropriate evaluation of roof and wall framing using the following methodology:

Roof framing

- 5.4.5 With roof framing, including trusses, the critical deflection limit will be that corresponding to free span bending, and as a consequence, ceiling distortion orthogonal to the truss line due to the proximity of adjacent rigid or semi rigid supports. Strength may also need to be checked as well. For example, the loading of a bottom truss chord by a non-load bearing partition, where there is no camber or the camber gap is packed, resulting from the greater deflection due to the less stiff timber.
- 5.4.6 Documentation received from the software designer indicates that truss deflections are normally limited to span/300, but that the truss manufacturer imposed a maximum of 10mm mid-span deflection. This means free span deflection will not be an issue for most trusses.
- 5.4.7 Checks should take into account the actual moisture content of the truss framing. For example, the worst case scenario may be that less stiff re-graded NLB timber has had a moisture content exceeding 25% at the time both the roof sheathing and ceiling lining are installed (ceiling battens may have a moisture content less than 20% as per NZS 3602 permitting installation of the ceiling lining), which when considered with a rigid end wall, may result in unacceptable ceiling distortion.

Wall framing

- 5.4.8 With wall frames, minimum wall stiffness and wall deflections particularly with brittle wall claddings under serviceability loads should be considered.
- 5.4.9 It should be noted that the above checks are not necessarily conclusive and there may be other checks required to demonstrate compliance. This determination should in no way be construed as providing compliance support for another method of timber re-grading based on visual defect identification nor does it support the same methodology if used again. This is because the dataset only applies to the specific population of re-graded NLB timber which is the subject of this determination.
- 5.4.10 As a result of the re-graded NLB timber having been used in house framing there may be an increased incidence of people reporting deflection and distortion problems where NLB timber has been used. The incidence is likely to be related more to local distortions associated with lined framing, such as where trusses are in close proximity to non load-bearing walls and end walls, rather than where trusses are remote from these areas. In the latter cases, and in unlined ceiling situations such as garages, the increase should not be significant, since free span deflection is not generally the limiting criterion for short-to-medium span roof trusses.

6. Submissions in response to the draft determination

- 6.1 The draft determination was sent to the parties for comment on 2 July 2009.
- 6.2 The applicant, through the building products supplier, forwarded a detailed submission dated 20 August 2009. The building products supplier agreed with the factual summary of the matter to be determined but disagreed with several aspects including the reliance placed on the site visit made by the Department's officer as this could be construed as requiring 'ad-hoc on site [testing]'. The building products supplier questioned the draft determinations reference to the 'increased incidence of distortion' when the performance of the trusses in question had been verified by 'specific engineering analysis'. The building products supplier made detailed suggested changes to the draft determination.
- 6.3 The authority accepted the draft determination subject to comments made in a letter dated 24 August 2009. The authority accepted the information presented with respect to the subject house, but submitted that the determination needed to provide further guidance that could be applied in other situations where NLB timber has been used. The authority had concerns about the long term effects of the use of NLB timber with respect to deflection, and stated that it did not have sufficient information to be able to distinguish between 'acceptable' and 'normal' design limits. The authority maintained that building elements using NLB timber 'ought to be tested'.

- 6.4 The building products supplier requested the opportunity to further respond to the authority's submissions. The building products supplier made a further detailed submission to the Department dated 22 January 2010 to provide further context and background about deflection and the way the determination may be used to inform the assessment of other houses constructed from regarded NLB timber. The building products supplier noted that they have instigated a robust process of testing and analysis to determine the properties of the timber used. They review the trusses and frames on each house on a case by case basis.
- 6.5 I have carefully considered the matters raised by the authority and the building products supplier and have amended the draft determination as I consider appropriate.

7. Discussion

7.1 Notice to fix

- 7.1.1 I note that in the notice to fix under 'To remedy the contravention or non-compliance you must:' the notice also provided the option of applying for a determination as a way to remedy the contravention or non-compliance. As the applicant has applied for a determination the second condition of the notice to fix has been met.
- 7.1.2 It is my opinion that a notice to fix may require a building to be brought into compliance with the Building Code; however prescribing that a determination be applied for is not appropriate as a remedy within a notice to fix. I consider the suggestion of such a course of action is better suited to being included in a covering letter.

7.2 Compliance of the trusses

- 7.2.1 Based on the officer's comments and the specific engineering analysis founded on the statistically determined properties of the re-graded NLB timber used, I am prepared to accept that the trusses of the house addition comply with Clause B1 of the Building Code.
- 7.2.2 While I have concluded that these particular trusses are code-compliant, I also note the application of the methods used to establish code-compliance of the NLB timbers in this instance. The conclusions reached in this determination may assist, and be helpful to, building consent authorities in other circumstances to assess the structural performance of this specific population of re-graded NLB timber by using specific engineering analysis to show code-compliance. However, the tests and methods used in this determination will not automatically apply to other similar or future scenarios.

8. What is to be done now?

- 8.1.1 As I have found that the trusses are code-compliant, the authority should now withdraw its notice to fix. If it is of the opinion that the remainder of the building elements are also code-compliant, it should, subject to a request from the applicant, issue a code compliance certificate for the entire house additions.

9. The decision

9.1 In accordance with section 188, I hereby determine that:

- the roof trusses of the house addition comply with Clause B1 of the Building Code
- the decision of the authority to issue a notice to fix be reversed.

Signed for and on behalf of the Chief Executive of the Department of Building and Housing on 25 March 2010.

John Gardiner
Manager Determinations