

Stress Grading of Timber- Revision to Standards

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1. Introduction

NZS 3603:1993 Timber Structures Standard has been amended. This standard is the head standard for timber design- whether specific design or its flow on to the Acceptable Solution, NZS 3604. The document is therefore the basis for timber framed buildings in general and for the design of trusses and other components as well as for other timber design from garages to multi-storey buildings. A new standard NZS 3622, Verification of timber properties, has been created to complete the loop of performance based stress grading.

2. Why Amend 3603?

The problems with NZS 3603 included:

- The visual grading rules could not ensure that the NZS 3603 design properties were met with No1 framing grade which was not monitored.
- The interaction with documentation around machine stress grade involved a series of standards, some NZS, and some joint AS/NZS, which did not fit together and were not acceptable within the changing framework of the NZBC and the Approved Documents. Performance related systems were to be insisted on.
- The wood resource in NZ had changed since 1993 and the species listed were often not available (in particular the native species) and the grades listed for the exotic species were not available.
- The properties assigned to the pine and fir grades were not appropriate. The 1993 conversion from working stress design format to limit states design format had been an arbitrary soft conversion and some design strengths had always been too high.

3. Evidence of non-performance

Strength failures are rare in NZ. The most common type of failure is excessive deflection of lintels floors or roofs resulting in call backs for builders and complaints from home owners. This was the initial driver to amend NZS3603 which started before the present round of NZBC changes. At the same time weaknesses in the Australian machine stress grading system are showing up in that country.

4. What is Stress Grading

Stress grading assigns a grade to a stick based on a pre-determined association of an attribute with either a strength property and/or a stiffness property. Assigning a stress grade based on an attribute implies that there must be monitoring of stress levels to ensure that these are being achieved.

Over the years there have been two approaches to this;

- Visual Grading

Visual grading sorts timber into grades on the attributes of visual characteristics i.e. knots, pith, sloping grain.

Historically there have been rules for this for many years and No 1, & No 2 framing were such sorting rules. But there was no requirement to check the performance of the grading process or the performance of the timber. It was an assumption that the grade properties in NZS 3603 would be achieved. In the 1970's and 1980's this may have been the case. By 2002 there was substantial evidence that younger forests and different tree stocks had changed the variability particularly regarding stiffness

- Machine Stress Grading

Machine stress grading assigns a stress grade to a stick from the minimum local stiffness measured on the flat face of the stick. The grade is assigned by slotting the minimum local stiffness into threshold ranges. The thresholds are selected so that populations of the timber meet or exceeded characteristic strength and stiffness properties for the grade. These should be continuously monitored in the mill.

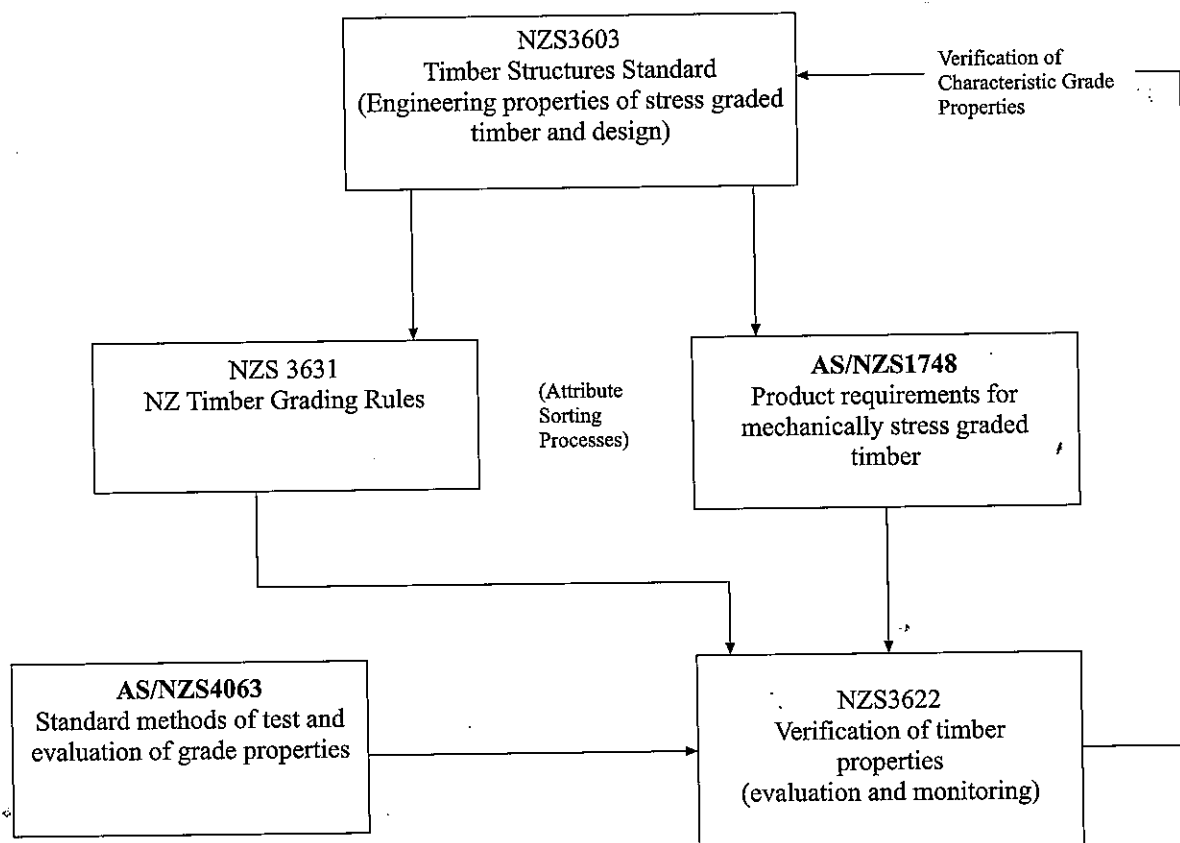
5. Why Write a New NZS3622?

There is a need for a standard that sets out the monitoring procedures for stress grading. There is a joint Australian/New Zealand standard (AS/NZS 4490) in this area but it had deficiencies. It did not apply to visually graded timber (and in the short term this will not go away in NZ) and the BIA/DBH perceived weaknesses in it. With the pressure to revise the timber grading system it seemed that the logistics of revising AS/NZS 4490 would create too much delay. NZS 3622 describes procedures for the initial evaluation and quality control requirements necessary to verify that timber has the structural properties claimed for it. It applies to both visually graded and machine stress graded timber. It requires audit of quality control procedures by a "suitably qualified organisation".

6. Variability of Timber

Visual grading is a poor system for grading for stiffness. Machine grading improves on this by assessing every piece for stiffness. NZS3622 and the revision to NZS3603 have established limits for stiffness to reduce variability at the lower end of the range. With MSG timber the variability reduces as the grades go up, ie the lower 5% value (ie the bottom end) is much closer to the average for MSG12 than for MSG8. This is known with some certainty because of the assessment of every stick. With VSG grades verification is based on sampling—measuring the performance of either a minimum of 30 specimens (batch basis), or of the last 30 taken. There is therefore a lower level of reliability than assessment of every stick as with MSG. There is no change in variability in going from VSG8 to VSG10 grade. By way of comparison MSG8/10 grades have less low end variability than VSG8/10 grades.

7. Stress Grading Flow Chart



What is new in this flow chart is this introduction of NZS3622 and the link to visual grading? Machine stress grading in the Australian MSG grading sequence always had a monitoring requirement. NZS3622 requires verification of both machine and visual stress grading results as part of a system with new grade names to identify product. If the producer opts not to verify his product it can still be sold and be labelled as No 1 Framing Grade. The verified visual and MSG products have specific marking requirements that do not apply to No 1 Framing grade.

8. The Amended NZS 3603

Deleted are

- Engineering grade radiata pine and Douglas fir
- Native species and larch (although larch if used can be bracketed with radiata pine for properties)
- F Grades

Added are:

- MSG 15, 12, 10, 8, 6 grades
- Visual stress grades VSG 10, VSG 8 (graded from dry, verified dry)
- Visual stress grade G8 (graded green, verified green)
- No 1 Framing Grade (graded green or dry, unverified, but with significantly lowered properties) ie a new grade
- A lower bound stiffness (Modulus of Elasticity) property in each grade. Elb. This is not a minimum value, about 5% of any parcel may have a lower stiffness than Elb. The term 5th percentile E is in the process not the design document.

Changes:

- The existing tables 2.2 and 2.3 in NZS 3603 are replaced by the following tables (notes omitted)

Table 2.2 – Characteristic stresses for visually graded timber (MPa)

1. Moisture condition - Dry (m/c = 16 %)						
Species	Grade	Bending strength f_b	Compression strength f_c	Tension strength f_t	Modulus of Elasticity E (GPa)	Lower Bound Modulus of Elasticity E_{lb} (GPa)
Radiata Pine & Douglas Fir	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 ¹	10.0	15.0	4.0	6.0	4.0
2. Moisture Condition – Green (m/c = 25 %)						
Radiata Pine	VSG10 VSG8 G8 ²	11.7	12.0	4.0	6.5	4.4
	No 1 Framing ¹	7.5	11.0	3.0	4.8	3.2

Table 2.3 - Characteristic stresses for machine stress graded timber (MPa)

1. Moisture condition – Dry (m/c = 16 %)						
Species	Grade	Bending strength f_b	Compression strength f_c	Tension strength f_t	Modulus of Elasticity E (GPa)	Lower Bound Modulus of elasticity E_{lb} (GPa)
Radiata Pine & Douglas Fir	MSG15	41.0	35.0	23.0	15.2	11.5
	MSG12	28.0	25.0	14.0	12.0	9.0
	MSG10	20.0	20.0	8.0	10.0	7.5
	MSG8	14.0	18.0	6.0	8.0	5.4
	MSG6	10.0	15.0	4.0	6.0	4.0

- Design for deflection – the existing clause 2.4.2 is replaced by the following (full details include 2.4.2.1, 2.4.2.2, 2.4.2.3)
- 2.4.2 Modulus of elasticity
- 2.4.2.1 General
The modulus of elasticity used for the design of timber elements depends on the degree to which they are part of a system and therefore constrained to deformation similar to that of their neighbours

9. The New NZS 3622

This document is in effect the outline of the process which the producer must follow to be able to claim the grade values for timber. At the mill the target grade values are set out in tables 5.1 and 5.2.

Table 5.2 – Minimum target values for machine stress graded timber

Moisture condition – Dry (m/c = 16 %)						
Species	Grade	Bending strength f_b (MPa)	Compression strength f_c (MPa)	Tension strength f_t (MPa)	Modulus of elasticity E (GPa)	Fifth percentile modulus of elasticity $E_{0.05}$ (GPa)
Radiata pine & Douglas fir	MSG15 MSG12 MSG10 MSG 8 MSG 6					

- The producer of stress graded timber is required to continuously monitor, in mill, these properties ie there are 3 parameters to monitor
 - Bending strength f_b
 - Modulus of elasticity E
 - 5th %ile modulus of elasticity
- To have this monitoring independently audited - but by whom ? It says by a “suitably qualified organisation”. The adequacy of this organisation is not defined .
- To mark the grade on each stick and to exclude non-conforming product.

10. Changes in Grade Properties

a. Visual Grades

Effectively VSG 8 takes over from the *old* No 1 framing grade as the “standard building grade”. By way of comparison with the *old* No 1 Framing Grade

VSG8 has:

- The same average stiffness (but with the addition of a lower bound to stiffness where none previously existed)
- Lower bending strength
- Lower tension strength

And VSG10 has:

- Higher average stiffness
- Higher bending strength
- The same tension strength

And the new No 1 Framing Grade has:

- Lower average stiffness
- Much lower bending strength
- Much lower tension strength

b. Machine Stress Grades

These are new grades and comparison with the previous NZS 3603 is also on the basis of the *old* No 1 Framing grade. MSG 10 and 8 compare as for VSG 10 and 8 (as above) for strength and for stiffness

MSG12 has substantially higher values for stiffness

Bending strength
Tension strength.

11. Large Size Timbers

The whole focus of the verification standard and of both machine and visual stress grading has been around building framing timbers ie 35mm and 45 mm widths in various depths. There is no process for 75mm or 100mm width timbers to be verified as MSG or VSG unless they can be dried for verification. This presents a challenge. This leaves them in the position of being G8 and verified or No 1 framing grade and unverified. Whether producers will set up to do such verification is unclear.

12. Flow-on to NZS 3604

NZS 3604 is to be amended to reflect the changes to NZS 3603. The timetable and procedure for this is not known but it should be published in late 2005 by Standards NZ. The following notes are related to this update.

- a. It is expected that span tables in the main document will be in terms of 2 grades ie existing tables will generally be duplicated. These will be for MSG8/VSG8 and *new* No 1 F grade. Those for No 1 F grade may be an appendix. It is expected that there will be supplement for tables for grades MSG10/VSG10 and perhaps MSG12.
- b. for MSG8/VSG8 there will be
 - i. No difference for spanning members such as floor joists and rafters from existing tables
 - ii. A modest affect on load/span tables for lintels and beams ie for isolated spanning members
 - iii. An undefined (but probably marginal) affect on exterior studs but not plates
- c. For *new* No 1 framing grade there will be new tables reflecting the reduced performance ability of this grade. This grade is significantly penalised.
- d. The effect on bearers has not been predicted by any observers but unless these can be verified into a G8 grade these will be penalised. Posts in the sense of deck posts are probably not affected.

13. Flow – on to Specific Design Buildings and Components

- a. Trusses. The low performance of new No 1 framing will just about exclude this grade from truss chords. MSG 8/VSG 8 is limited by its tension performance to chords of small or lightly loaded trusses. Expect to see 10 and 12 grades in other trusses. Whether the market adopts both grades remains to be seen but truss and frame manufacturers indicate they will stock one “truss grade” only.
- b. Small buildings. Eg garages, probably no change from the present use of MSG 8 but users of *old* No 1 framing may change to an 8 grade.
- c. Farm buildings. Traditionally these have made use of H3.2 (ie CCA treated) rough sawn No 1 Frame. The issues over verifying this to an 8 grade may mean that all this timber goes out as the *new* No 1 framing grade. On this basis it is penalised. Mills for which this is significant volume may opt to verify this as a G8 or MSG8 grade.
- d. Other structures eg wharf, bridge structures. It depends on whether these are deflection or strength dependant. If deflection controlled and involving members in isolation going to an 8 grade will have only a small effect, changing to *new* No 1 framing will have a greater change. If strength controlled, an 8 grade will affect the sizing but going to the *new* No 1 framing will have a major impact.

14. Availability of Grades

- a. Visually Graded
 - VSG 10 and VSG 8 are required to be verified in the final size, surface finish and moisture condition (ie dry). They will therefore have come from a producer able to meet these conditions. There are no visual attributes to distinguish between the 8 and 10 grades that are published. That is, either a site will yield VSG10 or it won't. It is not possible to get both from the same wood sort. There are few if any sites that will yield VSG10 in radiata pine but it may be available in Douglas Fir. Verified VSG 8 may be available in both species and it is expected that G8 in H3.2 CCA radiata will be available. For some producers special effort will be needed in relation to log supply cutting and grading to get VSG 8 or G8.
 - VSG10 may be unavailable. It may prove to be not possible (or not practical) to control the stiffness (E or Elb) parameters.
 - G8 as a verified green grade may be available.
 - *New* No 1 framing grade will continue to be available particularly from smaller mills and from sites where the wood resource will not yield sufficient material with a mean modulus of elasticity of 8. This is expected to be in parts of the lower North Island and South Island

b. Machine Stress Graded

- MSG 15 is unlikely to be available from any NZ timber production site. It may be sourced overseas eg Australia
- MSG 10 and 12 are being supplied to meet the particular needs of the truss manufacturers. Availability in sizes greater than 140mm depth is doubtful. If MSG 12 is being specified check its availability.
- MSG 8 is seen as a standard framing grade and it may be used in less demanding trusses and in truss webs. For the larger truss and frame manufacturers it will be the basic wall/floor framing stock line and they will need to hold stock of 12 and/or 10 grades for truss chords and girder trusses. Many (frame and truss producers) stated a preference to be single grade sites but the tension properties of this grade make it uneconomic in a number of trusses.
- MSG 6 may not be commercially available. There is a reason for this that is best put this way. Why would a producer spend the time and money on a grade evaluation, on testing and monitoring on marking and on audit to sell against a matching grade that has the same properties assigned to it just by looking at it? (ie *new* No 1 Framing grade).