Ensuring Material Performance Meets Design

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Underpinning any structural design is the assumption that the material chosen has the structural performance called up in the actual design. As designers, we are commonly asked to span greater distances, carry greater loads in an effort to produce economic designs. An example of this is the specifically designed multi-storey apartment buildings where the axial load capacities of the wall-framing studs are being pushed to their limits. It is in these circumstances where the assumption about the material becomes more and more critical. Client expectations can also be quite demanding and the threat of legal action bought on a structure performing outside the customer's expectation is very real.

In specifically designed structures with obvious, deliberate, and discrete load paths any differences between design properties and supplied properties can reflect negatively on the performance of the structure, as there is no redundancy or 'load sharing' ability, which there tends to be for buildings designed under NZS3604. For instance if the timber design uses a Modulus of Elasticity of 10GPa and say the timber supplied has a average MoE of 8.5 GPa then all the calculated deflections could be increased by up to 18%.

It is not only structural engineers who place this reliance on timber properties, essentially anybody who orders structural timber on the basis on grade is in the same situation. This will include:

Timber truss designers and manufacturers
Glue laminated timber producers
Domestic house builders

One way to counter this is for structural engineers to produce a set of project specifications and drawings, which amongst other things, set out the required material performance and how this is to be monitored for compliance during the construction.

Typically for steel concrete and masonry, engineers have produced specifications which require compliance with certain standards and a means for testing to ensure compliance.

Timber on the other hand can be specified as visually graded, where there is no guarantee of stiffness or it can be specified as machine stress graded which gives good control of stiffness but not necessarily strength.
In the very near future MGP grades will be available (machine graded pine) whereby an MGP8 grade will be available, which will approximate to the old No1 framing with respect to the characteristic stresses. In specifying MGP grades we can have more confidence in the supplied product having the properties used in design.
Even with machine stress graded timber, our structural specifications should still include the option of testing, when the engineer believes that his or her design is pushing the material to its limits of strength and/or stiffness. This should be a judgement call that the engineer can make.

Timber (even with visual or machine grading) is a product with greater inherit variation than, say, steel, so the importance of specification of timber for a project should be more critical.

This apparent general acceptance of timber properties without verification could be judged by some as giving timber an unfair advantage over the other construction materials. All timber producers committed to the long-term use of structural timber should welcome the inclusion of an on-site material property checking procedure. After all, their competitors accept this form of material property monitoring.

A suggested clause in a project specification for timber framed construction could be as follows:

Testing

A sample of not less than thirty pieces shall be selected at random on a size by grade by supplier basis by the engineer for independent destructive testing. The testing shall be performed in accordance with AS/NZS4063:1992 "Timber- Stress graded-In grade strength and stiffness evaluation". The standard testing regime will be based on bending testing to determine bending strength and stiffness. However, as directed by the engineer, testing for tension, compression and shear properties can also be called for, if these properties are critical in the design.

Non-Conformance / Conformance

Where the calculated timber properties (by AS/NZS4063:1992) are not achieved in the first test batch, the engineer can request an additional sample for testing. If this sample meets the grade properties the timber could be deemed to be acceptable, if not, then all the timber in that size by grade by supplier shall be removed from site.

Additional testing

At the engineers discretion additional testing for the strength properties can be required if: there is an apparent reduction in timber quality, a change in timber supplier, change in grade or size.

Organisations such as the Universities, Forest Research or BRANZ are capable of carrying out such testing, and the cost of this testing will only be approximately $1000.00 per 30 pieces tested per type of test. This small cost is similar to those costs incurred for say monitoring concrete strength or weld inspections and compared against the risk of having a poorly performing structure, is money well spent.