TIMBER FASTENING TECHNICAL NOTE

AEFAC
Australian Engineered Fasteners and Anchors Council

AEFAC – TFTN01

JOINT GROUPS FOR TIMBER FASTENERS AND CONNECTORS

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1. Objective

The objective of this Technical Note is:

- To provide background information about joint groups for connection design.
- To clarify the selection of joint groups in accordance with AS 1720.1 (Standards Australia, 2011) and AS 1649 (Standards Australia, 2001).
- To provide guidance for the selection of joint groups for engineered wood products (EWP).

2. Background to joint groups

In Australia, timber has been classified into joint groups for the purpose of calculating joint capacity. Unseasoned timber is classified into six joint groups; J1 to J6 and seasoned timber is classified into six joint groups JD1 to JD6. For seasoned timber species, JD1 has the highest joint strength properties and JD6 has the lowest. Similarly, for unseasoned timber species, J1 has the highest strength properties and J6 has the lowest.

Joint group classification based on timber species or species group is provided in AS 1720.1:2010, the Australian Standard on *Timber structures - Part 1: Design methods*. Joint group classification based on timber density is specified in AS 1649:2001, the Australian Standard on *Timber – Methods of test for mechanical fasteners and connectors – basic working loads and characteristic strengths.*

3. Selection of joint groups in accordance with AS 1720.1 and AS 1649

3.1. Scope

The joint group classifications are for the design of fasteners in accordance with AS 1720.1 and may not necessarily apply to proprietary fasteners. The joint group classifications are particularly suitable for fastener Categories A, B, and D (as defined in AS 1649), for example, nails, screws, bolts and coach screws, and are not necessarily applicable for Category C fasteners such as multi-toothed nailplates.

3.2. AS 1720.1

AS 1720.1:2010 refers to **Table H2.3, H2.4,** and **H3.1** for the joint group classifications for a range of timber species or species group.

The following information is provided in the relevant tables:

- **Table H2.3** – shows the strength group, joint group, and design densities for some common hardwood species.
- **Table H2.4** – shows strength group, joint group, and design densities for some common softwood species.

- **Table H3.1** – shows various characteristic values, joint group, and design densities for MGP10, MGP12, MGP15, and A17 stress grades.

As stated in AS 1720.1, the design densities which are provided are only for calculating dead load due to the mass of the timber. It should not be used for the design of joints.

The classification of joint groups based on stress grading alone is not sufficient since the grading of timber is based on the modulus of elasticity (MOE) and strength data (as explained in AS/NZS 1748.2:2011). The stress grading does not account for the density of timber and hence the classification for the joint group may not be consistent for various timber species which may have the same stress grade.

The classification of joint group based on stress grading in Table H3.1 appears to be only applicable for typical Australian-grown radiata pine. However, there are species of timber, from overseas or in Australia, that can have lower densities than those assumed in Table H3.1 for a stress grade. For timber outside of the density range corresponding to the joint groups in Table H3.1, an alternative joint group will apply and must be provided by the supplier. If the supplier does not specify the joint group, then the use of the Australian Standards for connection design is not valid.

3.3. AS 1649

AS 1649:2001 defines joint groups based on mean density for the purpose of establishing design loads for fasteners for a joint group. The mean density range for joint groups in accordance with AS 1649:2001 for seasoned timber is shown in Table 1.

Table 1: Mean density range for joint groups in accordance with AS 1649:2001 for seasoned timber (group mean air-dry density at 12% moisture content)

Joint group	Minimum density for joint group (kg/m^3)	Maximum density for joint group (kg/m^3)	Average density for joint group (kg/m^3)
JD1	940	-	-
JD2	750	935	842.5
JD3	600	745	672.5
JD4	480	595	537.5
JD5	380	475	427.5
JD6	300	375	337.5

It is stated in AS 1649 that the density of "… the timber selected to represent the joint group shall be at the bottom end of the range of density…". This requirement is ambiguous and needs clarification when used in testing to determine the design strength of fasteners for a joint group.

The test results are acceptable for the assigned joint group if the mean timber density of the samples is equal to or lower than the average density of a joint group. If the mean timber density of the samples is higher than the average density of a joint group, then a correction for density is required for each sample to ensure that the design strength of the fasteners is not over-estimated for a joint group.

Furthermore, a correction for the density can be made when the mean density of the samples is lower than the average density of a joint group; if it is demonstrated that the failure in the timber, rather than failure in the metal, will take place for the fastener installed in timber with the mean value of the timber density for which the test results are applied.

As explained in ISO 8970:2020, the test results can be corrected for timber density using Eq. 1.

$$P_{tc,i} = P_{t,i}\left(\frac{\rho_{m,ref}}{\rho_{m,test}}\right)^{x} \qquad \text{Eq. 1}$$

Where

$P_{tc,i}$	=	corrected value of the strength resistance from the test data for test value i corrected to refer to $\rho_{m,ref}$
$P_{t,i}$	=	strength resistance from the test data for test value i
$\rho_{m,ref}$	=	mean value of the timber density of the reference population for which the test results are applied
$\rho_{m,test}$	=	mean value of the measured density of all timber pieces of the test specimens

The value of x is dependent on the fastener type, failure mechanism, and timber properties, especially the considered range of timber density. In this Technical Note, the following values for x is suggested:

$$x = 1.0 \text{ if } 0.90 \le \frac{\rho_{m,ref}}{\rho_{m,test}} \le 1.10$$

$$x = 0.8 \text{ if } 1.10 < \frac{\rho_{m,ref}}{\rho_{m,test}} \le 1.75$$

$$x = 2.0 \text{ if } 0.55 \le \frac{\rho_{m,ref}}{\rho_{m,test}} < 0.90$$

The equation for correcting for density (Eq. 1) has been developed to adjust test results when the mean density of the specimens is slightly different to the mean density of the reference population. However, the equation may be used for extrapolation of test results for reference populations with different mean values of timber density for the $\frac{\rho_{m,ref}}{\rho_{m,test}}$ limits provided, and is likely to give conservative results as the value of $x = 2$ or $x = 0.8$ are generally conservative values and are based on values provided in ISO 8970:2020 for various failure mechanisms of nails, staples, and screws in European softwood.

It is important to note that correction for timber density or extrapolation of test results for other reference populations using timber density should only be made for failure modes which are dependent on timber density. Furthermore, it is assumed that perpendicular to the grain tension failure does not govern the failure mode.

For accurate results, it is suggested that more testing is conducted for reference populations with different mean timber densities instead of extrapolation.

Extrapolation of test results using the above suggested x-values should not be used for $\frac{\rho_{m,ref}}{\rho_{m,test}}$ lower than 0.55 or higher than 1.75. These limits approximately correspond to two joint groups above or below the joint group which has been tested based on the mean density of the timber samples.

4. Selection of joint groups for EWP

The density for engineered wood products (EWP) varies significantly. Currently, the standards for EWP are predominantly concerned with ensuring that the products produced are repeatable and consistent. There are no requirements for their properties, i.e., there are no minimum thresholds that they need to meet. The properties for EWP are proprietary and hence the manufacturer/supplier needs to state the suitable joint group to be adopted for the design of connections.

There are questions about the suitability of using average density to determine joint groups since the density of an EWP may vary along its thickness. This especially applies to laminated veneer lumber (LVL) for which the surface layers typically have higher densities than the inner layers. This is also addressed in AS 1720.1, as it states that the joint group provided by a manufacturer for a LVL product and determined in accordance with AS/NZS 4357, apply for nails, screws, bolts, and coach screws, and that for other fasteners the use of the joint group may not be appropriate.

5. References

International Organization for Standardization. (2020). *ISO 8970:2020, Timber structures - Testing of joints made with mechanical fasteners - Requirements for timber density*. Switzerland: ISO

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Standards Australia/New Zealand Standards. (2005). *AS/NZS 4357.1:2005. Structural laminated veneer lumber (LVL) – Part 1: Method of test for measurement of dimensions and shape.* NSW and Wellington: Standards Australia and Standards New Zealand

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