Forest&Wood Products Australia
Knowledge for a sustainable Australia

MARKET ACCESS

PROJECT NUMBER: PN07.1052

August 2007

Manual10 – Commentary on a Proposed Timber Service Life Design Code

This report can also be viewed on the FWPA website

www.fwpa.com.au

FWPA Level 4, 10-16 Queen Street,
Melbourne VIC 3000, Australia
T +61 (0)3 9927 3200 F +61 (0)3 9927 3288
E info@fwpa.com.au W www.fwpa.com.au

USP2007/047

MANUAL NO. 10

Commentary on a Proposed Timber Service Life Design Code

R.H. Leicester, M. Nguyen and C-H. Wang

April 2008

This report has been prepared for Forest & Wood Products Australia (FWPA).

CSIRO

Please address all enquiries to:
Urban Systems Program
CSIRO Sustainable Ecosystems
P.O. Box 56, Highett, Victoria 3190

Acknowledgments

This Manual is one of a series of Manuals that have been produced as part of a project titled 'Design for Durability'. The authors are deeply indebted to the Forest and Wood Products Australia for their funding and collaboration in this project over the past 10 years. The authors would especially like to thank Colin MacKenzie (Timber Queensland) for the major role that he has played in managing and guiding this project to completion. Thanks go to Greg Foliente, Craig Seath, Sandra Roberts and numerous other CSIRO personnel for their assistance and contribution to this project.

Contents

EXECUTIVE SUMMARY 4
1. SCOPE 5
2. CONCEPTS 6
3. DERIVATION OF STATISTICAL PARAMETERS 7
4. BASIS 9
5. APPLICATION 10
6. EXAMPLE 12
REFERENCES 14

Executive Summary

- The purpose of this document is to provide a commentary to, and explanation of, the document titled "A draft proposal for AS1720.5: Timber Service Life Design Code" That document is intended to give procedures for taking into account the effects of durability in the engineered design of timber structures.
- Source documents that provide the derivation of the durability models and the related reliability analysis are listed and discussed.
- The format of the Code and aids for application are described.
- An example of application of the Code is given.

1. SCOPE

The purpose of this document is to provide a commentary to, and explanation of, the document titled “A draft proposal for AS1720.5: Timber Service Life Design Code” That document is intended to give procedures for taking into account the effects of durability in the engineered design of timber structures. The following attack scenarios are considered:

- attack of in-ground timber by decay fungi
- attack of above-ground exposed timber by decay fungi
- attack of timber by marine borers
- corrosion of metal fasteners due to airborne salt, polluting agents, or timber acidity

The procedure to be used is similar to that of AS1720.4-Timber Structures-Fire-resistance of Structural Timber Members. Equations are provided for computing the loss of section due to attack by the various agents listed above. The residual section is then assumed to be its original strength (less any relevant load duration factors).

2. CONCEPTS

The procedure to be used is similar to that of AS1720.4-Timber Structures-Fire-resistance of Structural Timber Members. Equations are provided for computing the loss of section due to attack by the various agents listed above. The residual section is then assumed to be its original strength (less any relevant load duration factors).

The format used to compute the effective depth of attack by a biological or environmental mechanism, d_{eff} is given by

$$d_{eff} = d\left(1 + \alpha V_d\right) \quad (1)$$

where d is the mean depth of the loss in cross-section due to either biological or corrosion attack for a chosen design life L_{design}; V_d is the coefficient of variation of d; and α is a specified parameter related to the target reliability level.

In the proposed Code, the recommended values for the coefficient of variation V_d are as given in Table 1.

Table 1. Recommended values for the coefficient of variation V_d

Attack scenarios	V_d
Decay inground	1.5
Decay above ground	2.0
Marine borer attack	1.5
Embedded corrosion of fastener	2.0
Atmospheric corrosion of fastener	1.5

For the case of tension members corroding on one surface only, the value of α to be used is 0.15. For all other types of members the value of α to be used is 0.8 and 0.4 for normal and low consequence of failure elements respectively.

We consider a structural element for a given design life. We then make the assumption that (a) the design load is the same, no matter what the length of the life and (b) that the design strength is a constant value and is equal to the strength that exists at the end of the design life. These are both conservative assumptions.

3. DERIVATION OF STATISTICAL PARAMETERS

The statistical procedure used to evaluate the design strength was based on a simplified approximation procedure used by Ravindra and Galambos (1978). In this procedure the value of the R_{design}, the design strength, is taken to be given by

$$R_{design} = 0.9\bar{R}\ \exp(-0.6\beta V_R) \tag{2}$$

where β design denotes a reliability index.

To evaluate R_{design}, the load capacity R of a structural element is taken to be given by

$$R = g(d) \bullet f \tag{3}$$

Where d is the depth of decay or corrosion, $g(d)$ is a geometrical function of d, and f is the ultimate strength of the material that has not been attacked by decay, corrosion etc.

To a first approximation we can take the mean value of load capacity $\bar{R}$ and variance of strength σ_R to be given by Ang and Tang (2007)

$$\bar{R} = g(\bar{d})\ \bar{f} \tag{4}$$

$$\sigma_R^2 = \sigma_d^2 \left(\frac{\partial R}{\partial d}\right)^2_{d=\bar{d}, f=\bar{f}} + \sigma_f^{\,2} \left(\frac{\partial R}{\partial f}\right)^2_{d=\bar{d}, f=\bar{f}} \tag{5}$$

Hence the coefficient of variation of load capacity V_R is given approximately by

$$V_R^2 = \left(\sigma_R / \bar{R}\right)^2$$

$$= V_{dur}^2 + V_f^2 \tag{6}$$

where V_f is the initial coefficient of variation of the load capacity for material that has not been attacked by decay, corrosion etc, and V_{dur} is given by

$$V_{dur} = -V_d \bar{d} \left(\frac{\partial g}{\partial d} \right)_{d=\bar{d}} / g\left(\bar{d}\right) \tag{7}$$

Finally, by a process of trial and error, for any given structural element and reliability index β a value of α can be chosen so that use of the loss of section d_{eff} according to equation (1) matches the loss in load capacity as given by equation (2). The detailed computations for this have been given in document "Manual No.2. Reliability Equations" by Leicester *et al* (2008).

4. BASIS

In drafting the Design Code, the derivation of the models used to compute the loss of section has been given in the following documents:

- Wang, C-H., Leicester, R.H. and Nguyen, M.N. (2008)“Manual No. 3: Decay in ground contact.”
- Wang, C-H., Leicester, R.H. and Nguyen, M.N. (2008) “Manual No. 4: Decay above-ground.”
- Nguyen, M.N., Leicester, R.H. and Wang, C-H. (2008) “Manual No. 5: Atmospheric corrosion of fasteners in exposed timber structures.”
- Nguyen, M.N., Leicester, R.H. and Wang, C-H. (2008) “Manual No. 6: Embedded corrosion of fasteners in exposed timber structures.”
- Nguyen, M.N., Leicester, R.H. and Wang, C-H. (2008) “Manual No. 7: Marine borer attack.”

5. APPLICATION

The Code provides assistance to the designer in a variety of ways such as by giving durability classifications for a large number of timber species and hazard zone classifications for a large number of cities and towns. It also gives suggestions for typical attack patterns such as that shown in Figure 1 below.

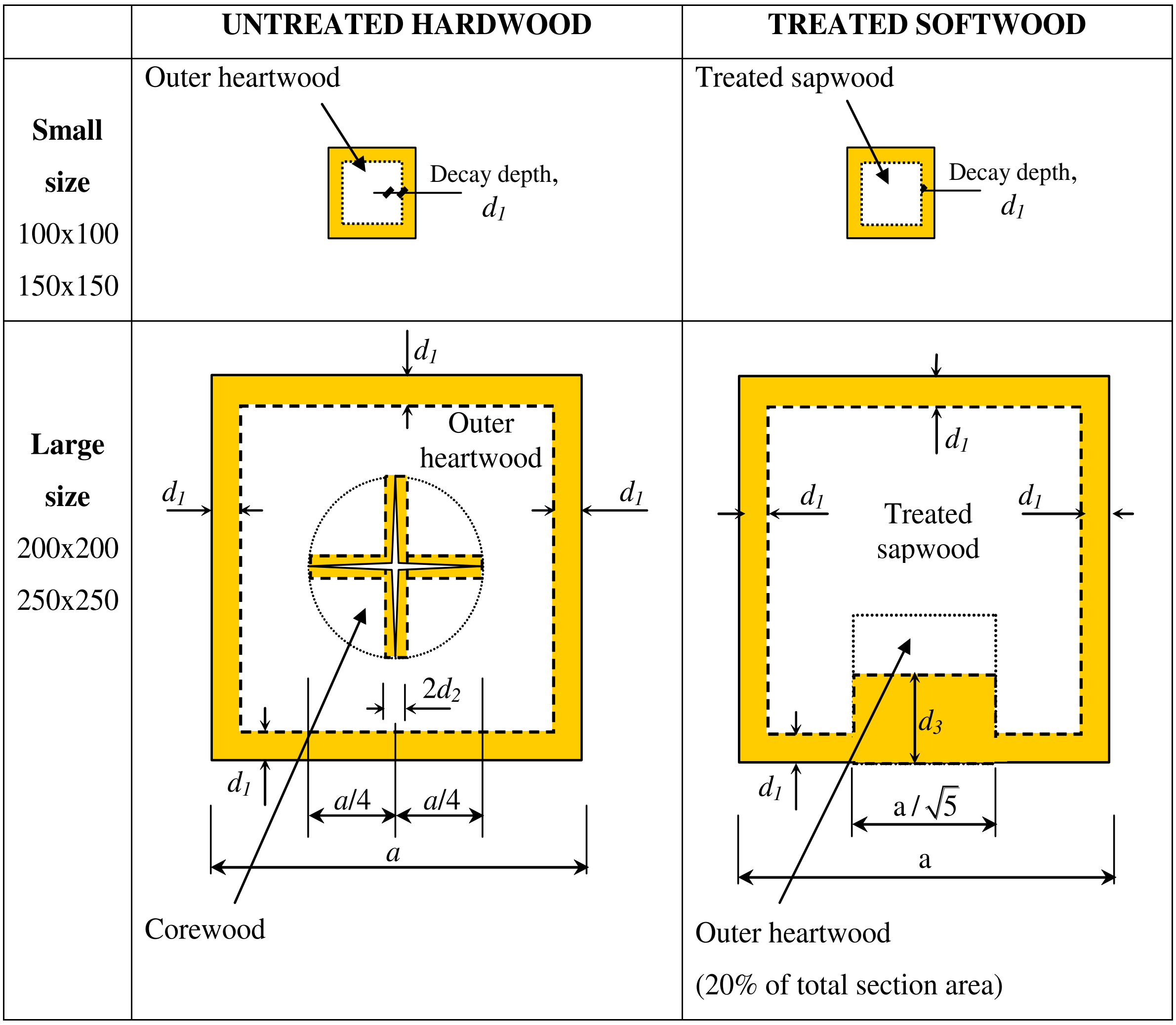

Figure 1. Decay patterns for square section posts

Evaluation of the mean attack depth usually involves complex computations involving many parameters. To assist the user of the Code, the Appendices contain numerous computed Tables that cover most commonly used engineering constructions.

The Code is structured so that the loss of section is intended to lead to designs that have an adequate reliability against structural collapse. However, the Code may also be used to used to estimate serviceability and replacement limits such as the following:

- For **above-ground construction,** the acceptable depths of surface decay may be taken to be 2mm and 10mm for serviceability and replacement limit states respectively.
- For **marine piles**, a limit of a 200mm diameter of the residual section is often taken to be a suitable criterion for replacement.
- For **structural components,** replacement when computed mean strength loss is 30%

6. EXAMPLE

As an example of the application of the Code, we will consider the bending strength at the ground-line of a pole with the following specifications:

- Low consequence of failure
- Pole diameter = 300 mm
- De-sapped
- Red Stringybark (Class 2)
- Melbourne (zone B)
- Diffusing external bandage applied at 15 years and 20 years

For this case we assume α = 0.4 and V_d = 1.5. The diffusing bandage is assumed to halt the perimeter decay for 5 years on each application. The loss in load capacity with time, computed by the draft Code, is shown in Figure 3.

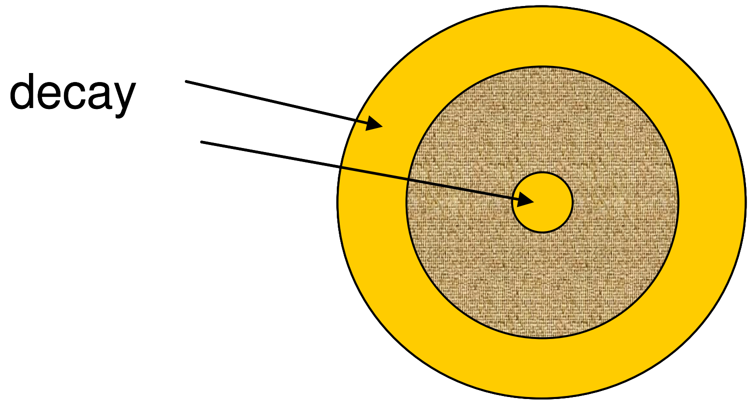

Figure 2. Assumed pattern of decay

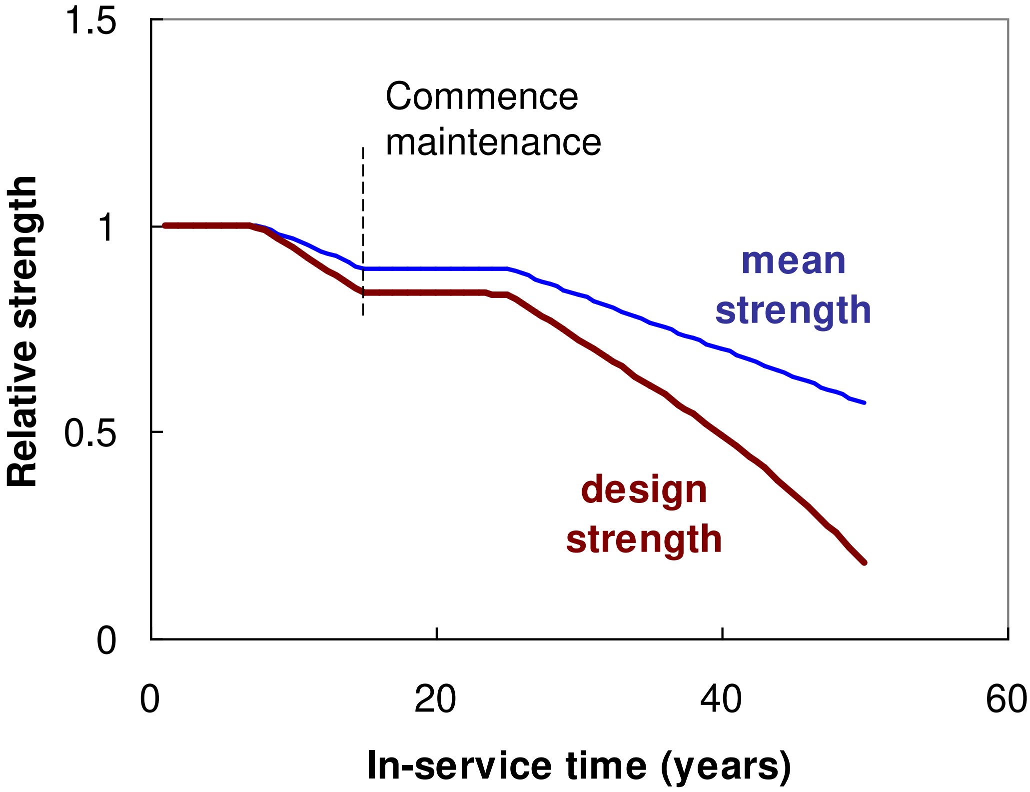

Figure 3. Computed effect of durability on relative strength

REFERENCES

Ang, A.H.S and Tang, W.H. (2006) Probability concepts in engineering. Emphasis on applications to civil and environmental engineering. John Wiley and Sons.

Leicester, R. H., Nguyen, M. N. and Wang, C-H. (2008). "Manual No. 2: Reliability Equations." http://www.timber.org.au/, April 2008.

Nguyen, M.N., Leicester, R.H. and Wang, C-H. (2008) "Manual No. 5: Atmospheric corrosion of fasteners in exposed timber structures." http://www.timber.org.au/, April 2008.

Nguyen, M.N., Leicester, R.H. and Wang, C-H. (2008) "Manual No. 6: Embedded corrosion of fasteners in exposed timber structures." http://www.timber.org.au/, April 2008.

Nguyen, M.N., Leicester, R.H. and Wang, C-H. (2008) "Manual No. 7: Marine borer attack." http://www.timber.org.au/, April 2008.

Nguyen, M.N., Leicester, R.H. and Wang, C-H. (2008) "A draft proposal for AS1720.5: Timber Service Life Design Code" http://www.timber.org.au/, April 2008.

Ravindra, M. K. and Galambos, T. V. (1978) Load and resistance factor design for steel. Journal of the Structural Division Proc. Of ASCE 104, ST9, Sept 1331-1354.

Wang, C-H., Leicester, R.H. and Nguyen, M.N. (2008) "Manual No. 3: Decay in ground contact." http://www.timber.org.au/, April 2008.

Wang, C-H., Leicester, R.H. and Nguyen, M.N. (2008) "Manual No. 4: Decay above-ground." http://www.timber.org.au/, April 2008.