9. Appendix

9.1 Appendix A: Sample Calculations
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9.1 Appendix A: Sample Calculations

9.1.1 Fairfax County Deck Details

The following calculations correspond to Section 4.1.

9.1.1.1 Joist Span

2x6 No. 2 Southern Pine, 16 in. oc,
40 psf Live, 10 psf Dead

\( F_b = 1250 \text{ psi}, F_v = 90 \text{ psi}, S = 7.563 \text{ in.}^3, l = 20.80 \text{ in.}^4 \)

9.1.1.1.1 Design with bending

\[
\begin{align*}
  f_b & \leq F_b' \\
  F_b' & = F_b C_F C_D C_I C_M = 1250 \times 1.0 \times 1.0 \times 1.15 \times 1.0 \times 0.85 = 1222 \text{ psi} \\
  w_j & = \frac{(40 \text{ psf} + 10 \text{ psf}) \times 16\text{ in}}{12 \frac{\text{ in}}{\text{ ft}}} = 66.67 \frac{\text{ lb}}{\text{ ft}} = 5.56 \frac{\text{ in}}{\text{ lb}} \\
  L & = \sqrt{\frac{8 F_b' S}{w_j}} = \sqrt{\frac{8 \times 1222 \times 7.563 \text{ in}^3}{5.56 \frac{\text{ in}}{\text{ lb}}}} = 115.3 \text{ in} = 9'7''
\end{align*}
\]

9.1.1.1.2 Check Shear

\[
\begin{align*}
  f_v & \leq F_v' \\
  F_v' & = F_v C_F C_D C_M = 175 \times 1.0 \times 1.0 \times 0.97 = 170 \text{ psi} \\
  V_{\text{max}} & = \frac{w(L^2 + a^2)}{2L} = \frac{5.56 \frac{\text{ lb}}{\text{ in}} (115\text{ in})^2 + (36\text{ in})^2}{2 \times 115\text{ in}} \approx 351 \text{ lb}
\end{align*}
\]
9. Appendix A: Sample Calculations

\[ f_v = \frac{3V_{\text{max}}}{2bd} = \frac{3 \times 35 \text{ lb}}{2 \times 1.5 \text{ in} \times 5.5 \text{ in}} = 64 \text{ psi} \]

\[ f_v = 64 \text{ psi} \leq F'_{v} = 170 \text{ psi} \quad \text{OK} \]

9.1.1.1.3 Check Deflection

\[ \Delta_{\text{max}} \leq \Delta_{\text{allowable}} \]

\[ \Delta_{\text{allowable}} = \frac{L}{360} = \frac{115 \text{ in}}{360} = 0.32 \text{ in} \]

\[ w_{\text{LL}} = \frac{40 \text{ psf} \times 16 \text{ in}}{12 \text{ in}} = 53.3 \text{ \#/ft} = 4.4 \%_{n} \]

Midpoint of span, \(x = 57.5"\)

\[ \Delta_{\text{max}} = \frac{w_{\text{LL}}x}{24EI} \left( L^4 - 2L^2x^2 + Lx^3 - 2a^2L^2 + 2a^2x^2 \right) \]

\[ = \frac{4.4 \%_{n} \times 57.5 \text{ in}}{24 \times 1,600,000 \text{ psi} \times 20.80 \text{ in}^4 \times 115 \text{ in}} \]

\[ \left( (115 \text{ in})^4 - 2(115 \text{ in})^2 (57.5 \text{ in})^2 + (115 \text{ in})(57.5)^3 - 2(36 \text{ in})^2 (115 \text{ in})^2 + 2(35 \text{ in})^2 (57.5 \text{ in})^2 \right) = 0.23 \text{ in} \]

End of overhang, \(x = 36"\)

\[ \Delta_{i} = \frac{w_{\text{LL}}x_i}{24EI} \left( 4a^2L - L^3 + 6a^2x_i - 4ax_i^2 + x_i^3 \right) \]

\[ = \frac{4.44 \%_{n} \times 36 \text{ in}}{24 \times 1,600,000 \text{ psi} \times 20.80 \text{ in}^4} \]

\[ \left( 4(36 \text{ in})^2 (115 \text{ in}) - (115 \text{ in})^3 + 6(36 \text{ in})^2 (36 \text{ in}) - 4(36 \text{ in})(36 \text{ in})^2 + (36 \text{ in})^3 \right) = 0.16 \text{ in upward} \]

\[ \Delta_{\text{max}} = 0.23 \text{ in} \leq \Delta_{\text{allowable}} = 0.32 \text{ in} \quad \text{OK} \]

9.1.1.2 Beam Size (Simple Span Joists)

Try: 2-2x8 No. 2 Southern Pine
F_b = 1200 psi, S = 13.14 in.³

9.1.1.2.1 Design with Bending

\[
\begin{align*}
    w_p &= \frac{w_j L_j}{2 \times \text{joist spacing} \times \text{plies}} = \frac{5.56\%}{2 \times 16\text{in} \times 2\text{plies}} = 10.0\% / \text{ply} \\
    F'_b &= F_b C_F C_D C_L C_M = 1200 \times 1.0 \times 1.0 \times 1.0 \times 1.0 \times 0.85 = 1020 \text{ psi} \\
    S_{req} &= \frac{w_p (L_b^2 + a_b^2)(L_b - a_b)^2}{8L_b^2 F'_b} = \frac{10.0\%}{8(96\text{in})^2 (1020 \text{ psi})} = 9.93\text{ in}^3 \\
    S_{req} &= 9.93\text{ in}^3 \leq S = 13.14\text{ in}^3 \quad \text{OK}
\end{align*}
\]

9.1.1.2.2 Check Shear

\[
\begin{align*}
    f_v &\leq F'_v \\
    F'_v &= F_v C_F C_D C_M = 175 \text{ psi} \times 1.0 \times 1.0 \times 0.97 = 170 \text{ psi} \\
    V_{max} &= \frac{w_p (L_b^2 + a_b^2)}{2L_b} = \frac{10.0\%}{2(96\text{in})} = 510\text{ lb} \\
    f_v &= \frac{3V_{max}}{2A} = \frac{3 \times 510\text{ lb}}{2 \times 10.9\text{in}^2} = 70 \text{ psi} \\
    f_v &= 70 \text{ psi} \leq F'_v = 170 \text{ psi} \quad \text{OK}
\end{align*}
\]

9.1.1.2.3 Check Deflection

\[
\begin{align*}
    \Delta_{max} &\leq \Delta_{allowable} \\
    \Delta_{allowable} &= \frac{L}{360} = \frac{96\text{ in}}{360} = 0.27\text{ in} \\
    \text{Midpoint of span, } x &= 48''
\end{align*}
\]
\[ \Delta_{\text{max}} = \frac{wx}{24EI} \left( L^4 - 2L^2x^2 + Lx^3 - 2a^2L^2 + 2a^2x^2 \right) \]
\[ = \frac{10.0 \text{ in}(48\text{ in})}{24(1,600,000 \text{ psi})(47.6\text{ in}^4)(96\text{ in})} * \]
\[ \left( (96\text{ in})^4 - 2(96\text{ in})^2(48\text{ in})^2 + (96\text{ in})(48\text{ in})^3 - 2(24\text{ in})^2(96\text{ in})^2 + 2(24\text{ in})^2(48\text{ in})^2 \right) = 0.12\text{ in} \]

End of Beam Overhang, x = 24"

\[ \Delta_i = \frac{wx_i}{24EI} \left( 4a^2L - L^3 + 6a^2x_i - 4ax_i^2 + x_i^3 \right) \]
\[ = \frac{10.0 \text{ in}*24\text{ in}}{24(1,600,000 \text{ psi})(47.6\text{ in}^4)} \left( 4(24\text{ in})^2(96\text{ in}) - (96\text{ in})^3 + 6(24\text{ in})^2(24\text{ in}) - 4(24\text{ in})(24\text{ in})^2 + (24\text{ in})^3 \right) \]
\[ = 0.08\text{ in upward} \]

\[ \Delta_{\text{max}} = 0.12\text{ in} \leq \Delta_{\text{allowable}} = 0.27\text{ in} \quad \text{OK} \]

9.1.1.3 Beam Size (Overhang on Joists)

Try: 2-2x10 No. 2 Southern Pine

9.1.1.3.1 Check Bending

\[ S_{\text{req}} = \frac{w_{\text{b}}(L_{\text{b}} + a_{\text{b}})^2}{8L_{\text{b}}^2 F'_{\text{b}}} = \frac{17.2 \text{ in}(96\text{ in} + 24\text{ in})^2}{8(96\text{ in})^2(1050 \text{ psi})} = 16.58\text{ in}^3 \]

\[ S = 21.39\text{ in}^3 \leq S_{\text{req}} = 16.58\text{ in}^3 \quad \text{OK} \]

9.1.1.3.2 Check Shear

\[ f_{\text{v}} \leq F'_{\text{v}} \]

\[ V_{\text{max}} = \frac{w_{\text{b}}(L_{\text{b}}^2 + a_{\text{b}}^2)}{2L_{\text{b}}} = \frac{17.2 \text{ in}(96\text{ in})^2 + (24\text{ in})^2}{2(96\text{ in})} = 877\text{ lb} \]
\[ f_v = \frac{3V_{\text{max}}}{2A} = \frac{3 \times 877 \text{lb}}{2 \times 13.9 \text{in}^2} = 95 \text{psi} \]

\[ f_v = 95 \text{ psi} \leq F'_{v} = 170 \text{ psi} \quad \text{OK} \]

### 9.1.1.3.3 Check Deflection

\[ \Delta_{\text{max}} \leq \Delta_{\text{allowable}} \]

Midpoint of span, \( x = 48'' \)

\[ \Delta_{\text{max}} = \frac{wx}{24EI} \left( L^4 - 2L^2x^2 + Lx^3 - 2a^2L^2 + 2a^2x^2 \right) \]

\[ = \frac{17.2 \text{ in} / (48 \text{in})}{24(1,600,000 \text{ psi})(98.9 \text{ in}^4)(96 \text{in})} \]

\[ \left( (96\text{in})^4 - 2(96\text{in})^2(48\text{in})^2 + (96\text{in})(48\text{in})^3 - 2(24\text{in})^2(96\text{in})^2 + 2(24\text{in})^2(48\text{in})^2 \right) = 0.10 \text{in} \]

End of Overhang, \( x = 24'' \)

\[ \Delta_i = \frac{wx}{24EI} \left( 4a^2L - L^3 + 6a^2x_i - 4ax_i^2 + x_i^3 \right) \]

\[ = \frac{17.2 \text{ in} / 24 \text{in}}{24(1,600,000 \text{ psi})(98.9 \text{ in}^4)} \left( 4(24\text{in})^2(96\text{in}) - (96\text{in})^3 + 6(24\text{in})^2(24\text{in}) - 4(24\text{in})(24\text{in})^2 + (24\text{in})^3 \right) \]

\[ = 0.07 \text{in upward} \]

\[ \Delta_{\text{max}} = 0.10 \text{in} \leq \Delta_{\text{allowable}} = 0.27 \text{in} \quad \text{OK} \]

### 9.1.1.4 Bolt Loading

10' Span, Bolts or Screws 14" oc

40 psf Live, 10 psf Dead

\[ \frac{Ls}{2} \left( LL + DL \right) = \frac{10 \text{ ft} \times 14 \text{in}}{2 \times 12 \text{in/ft}} \left( 40 \text{ psf} + 10 \text{ psf} \right) = 292 \text{lb} \]

9. Appendix A: Sample Calculations

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9.1.1.5 Guardrail Bending

4x4 No. 2 Southern Pine

\[ F_b = 1500 \text{ psi}, \ S = 7.146 \text{ in.}^3 \]

\[ f_b \leq F_b' \]

\[ F_b' = F_c C_f C_D C_E C_M C_p = 1500 \times 1.0 \times 1.0 \times 1.0 \times 0.85 = 1275 \text{ psi} \]

\[ M_{Max} = \frac{Pab}{L} = \frac{1705 \text{ lb} \times 38 \text{ in} \times 5.25 \text{ in}}{43.25 \text{ in}} = 790 \text{ in} - \text{lb} \]

\[ f_b = \frac{M}{S} = \frac{790 \text{ in} - \text{lb}}{7.146 \text{ in}^3} = 1106 \text{ psi} \]

\[ f_b = 1106 \text{ psi} \leq F_b' = 1275 \text{ psi} \quad \text{OK} \]

9.1.1.6 Post Adequacy

6x6 Post, Maximum 14' high, maximum 8' apart, 50 psf

\[ F_c = 565 \text{ psi}, \ E = 1,200,000 \text{ psi} \]

Tributary area = 8'x18'-9" = 150 ft²

\[ P = 50 \text{ psf} \times 150 \text{ ft}^2 = 7500 \text{ lb} \]

\[ f_c \leq F_c' \]

\[ f_c = \frac{P}{A} = \frac{7500 \text{ lb}}{5.5 \text{ in} \times 5.5 \text{ in}} = 248 \text{ psi} \]

\[ F_c' = F_c C_D C_F C_M C_p \]

\[ F_c' = F_c C_D C_F C_M = 565 \text{ psi} \times 1.0 \times 1.0 \times 0.91 = 514 \text{ psi} \]

\[ F_{cE} = \frac{K_{cE} E}{(l_c/d)^2} = \frac{0.3 \times 1,200,000 \text{ psi}}{(168 \text{ in} / 5.5 \text{ in})^2} = 386 \text{ psi} \]
\[ \frac{F_{cE}}{F_c^*} = \frac{386 \text{ psi}}{514 \text{ psi}} = 0.75 \]

\[ C_P = \frac{1 + \left( \frac{F_{cE}}{F_c^*} \right)}{2c} - \sqrt{\left( \frac{1 + \left( \frac{F_{cE}}{F_c^*} \right)}{2c} \right)^2 - \frac{\left( \frac{F_{cE}}{F_c^*} \right)}{c}} = \frac{1 + (0.75)}{2 \times 0.8} - \sqrt{\left( \frac{1 + (0.75)}{2 \times 0.8} \right)^2 - \left( \frac{0.75}{0.8} \right)} = 0.585 \]

\[ F_c^- = F_c^* C_P = 514 \text{ psi} \times 0.585 = 300 \text{ psi} \]

\[ f_c = 248 \text{ psi} \leq F_c^- = 300 \text{ psi} \quad \text{OK} \]
9.1.2 Full Deck Inspection Report Sample Calculations

The following calculations refer to Section 5.

9.1.2.1 Nomenclature for Sample Calculations

\( b \) = breadth of rectangular member, in.
\( C_b \) = bearing area factor\(^1\)
\( C_d \) = penetration depth factor\(^2\)
\( C_D \) = load duration factor\(^3\)
\( C_F \) = size factor\(^4\)
\( C_L \) = beam stability factor\(^5\)
\( C_M \) = wet service factor\(^6\)
\( C_p \) = column stability factor\(^7\)
\( C_r \) = repetitive member factor\(^8\)
\( C_{tn} \) = toenail factor\(^9\)
\( d \) = depth of rectangular member, in.
\( D_r \) = root diameter, in.
\( E \) = modulus of elasticity, psi
\( f_b \) = bending stress, psi
\( f_c \) = compressive stress parallel-to-grain, psi
\( f_{c,\text{perp}} \) = compressive strength perpendicular-to-grain, psi
\( f_v \) = shear stress parallel-to-grain, psi
\( F_{b, b'} \) = tabulated and allowable bending design value\(^{10}\), psi
\( F_{DE} \) = critical buckling design value for bending members, psi
\( F_{c, c'} \) = tabulated and allowable compression design value parallel-to-grain\(^{11}\), psi
\( F_{c, c_{\text{perp}}}, F_{c, c_{\text{perp}}'} \) = tabulated and allowable compressive design value perpendicular-to-grain\(^{12}\), psi
\( F_{cE} \) = critical buckling design value for compression members, psi

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\(^1\) Bearing Area Factor: NDS-01, Section 3.10.4
\(^2\) Penetration Depth Factor: NDS-01, Table 11J footnote 3.
\(^3\) Load Duration Factor: NDS-01, Table 2.3.2
\(^4\) Size Factor: NDS-01 Supplement Table 4A
\(^5\) Beam Stability Factor: NDS-01, Section 3.3.3
\(^6\) Wet Service Factor: NDS-01, Table 10.3.3
\(^7\) Column Stability Factor: NDS-01, Section 3.7.1
\(^8\) Repetitive member factor: NDS-01 Supplement, Table 4A
\(^9\) Toenail factor: NDS-01 Section 11.5.4
\(^10\) Bending: NDS-01 Supplement Table 4A and 4B
\(^11\) Compression: NDS-01 Supplement Table 4A and 4B
\(^12\) Compression perpendicular-to-grain: NDS-01 Supplement Table 4A and 4B
\[ F_v, F_v' = \text{tabulated and allowable shear design value}^{13}, \text{psi} \]
\[ G = \text{specific gravity}^{14} \]
\[ I = \text{moment of inertia}^{15}, \text{in.}^4 \]
\[ K_{bE} = \text{Euler buckling coefficient for beams}^{16} \]
\[ K_{cE} = \text{Euler buckling coefficient for columns}^{17} \]
\[ l_b = \text{bearing length parallel-to-grain, in.} \]
\[ l_e = \text{effective length}^{18}, \text{in.} \]
\[ l_u = \text{laterally unsupported span length, in.} \]
\[ M = \text{moment in bending member, in.-lb} \]
\[ p = \text{penetration into main member, in.} \]
\[ P = \text{concentrated load, lb} \]
\[ R_1 = \text{Reaction force at ledger for joists, lb} \]
\[ R_2 = \text{Reaction force at beam for joists, lb} \]
\[ R_{b} = \text{slenderness ratio of bending member} \]
\[ S = \text{section modulus}^{19}, \text{in.}^3 \]
\[ t_s = \text{thickness of side member, in.} \]
\[ V = \text{shear in bending member, lb} \]
\[ w = \text{uniformly distributed load, lb/in.} \]
\[ W, W' = \text{tabulated and allowable withdrawal design value, lb/in.} \]
\[ Z, Z' = \text{tabulated and allowable lateral design value, lb} \]
\[ \Delta = \text{deflection, in.} \]

9.1.2.2 Railings

9.1.2.2.1 Allowable loads

16d Threaded Nail in Withdrawal

D_r = 0.139 in., Effective Length = 3.3 in.

\[ G = 0.36 \]
\[ W = 1380G^{3/2}D = 1380 \times 0.36^{3/2} \times 0.139 = 14.9 \text{lbs/in.}^{20} \]
\[ W' = WC_M = 14.9 \times 1.25 \times 1.0 = 18.6 \text{lbs/in.}^{21} \]

---

13 Shear: NDS-01 Supplement Table 4A and 4B
14 Specific Gravity: NDS-01, Table 11.3.
15 Moment of Inertia: NDS-01 Supplement, Table 1B
16 Euler buckling coefficient, \( K_{bE} = 0.439 \) for visually graded lumber: NDS-01 Section 3.3.3
17 Euler buckling coefficient, \( K_{cE} = 0.3 \) for visually graded lumber: NDS-01 Section 3.7.1
18 Effective Length for a Beam: NDS-01, Table 3.3.3. For a post: NDS-01 Section 3.7.1.2 and Appendix G
19 Section Modulus: NDS-01 Supplement, Table 1B
20 Withdrawal Design Value: NDS-01, Section 11.2.3, eq 11.2-3
21 Adjustment Factors: NDS-01, Table 10.3.1
\[ p = l_c - t_s = 3.3\text{in} - 1.5\text{in} = 1.8\text{in} > 1.5'' \text{ thick band, therefore use 1.5 in.} \]

\[ W' = W''p = 18.625\text{lb/in} * 1.5\text{in} = 28\text{lb} \]

16d Threaded Nail in Shear

\[ t_s = 1.5 \text{ in}, \ D_r = 0.139 \text{ in.}, \ G = 0.36 \]

\[ Z = 79 \text{ lb}^{22} \]

\[ Z' = ZC_D C_M = 79\text{lb} * 1.25 * 1.0 = 99\text{lb}^{23} \]

1/2”x3” Lag Screw in Withdrawal

\[ D_r = 0.175 \text{ in.}, \ \text{Effective Length} = 2.75 \text{ in.}, \ G = 0.36 \]

\[ W = 1800G^{\frac{3}{2}}D_r^{\frac{3}{4}} = 1800 * 0.36^{\frac{3}{2}} * 0.175^{\frac{3}{4}} = 105\text{lb/in}^{24} \]

\[ W' = WC_D C_M = 105.2\text{lb/in} * 1.25 * 0.7 = 921\text{lb/in}^{25} \]

\[ p = l_c - t_s = 2.75\text{in} - 1.5\text{in} = 1.25\text{in}. \]

\[ W' = W''p = 92\text{lb/in} * 1.25\text{in.} = 115\text{lb} \]

1/2”x3” Lag Screw in Shear

From Excel Program:

\[ Z = 109 \text{ lb} \]

\[ Z' = ZC_D C_M = 67\text{lb} * 1.25 * 0.7 = 95\text{lb} \]

9.1.2.2.2 Actual loads

The actual loads were found using free body diagrams:

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\(^{22}\) Single shear, NDS-01, Table 11N

\(^{23}\) Adjustment Factors, NDS-01, Table 10.3.1

\(^{24}\) Withdrawal Design Value: NDS-01, Section 11.2.1, eq 11.2-1

\(^{25}\) Adjustment Factors, NDS-01, Table 10.3.1
50 lb/ft on cap rail

Figure 9.1. Free body diagram of 50 lb/ft load on cap rail. The load is horizontal and outwards from the deck. With the infill pickets spaced 8 in. on center, each picket carries 34 lb.

Figure 9.2. Free body diagram of infill picket. The 34 lb load is the reaction from the 50 lb/ft on the cap rail. The top connection (a lag screw or nail) must carry 252 lb in withdrawal.
1/2"x3" Lag screw: 252 lb > W' = 115 lb  NOT OK
16d Threaded Nail: 252 lb > W' = 33.5 lb  NOT OK

Exerted vertically downward, the 50 lb/ft load on the cap rail causes 17 lb in shear at each connection.

1/2"x3" Lag screw: 17 lb < Z' = 95 lb  OK
16d Threaded Nail: 17 lb < Z' = 99 lb  OK

50 lbs/ft² on infill picket

Figure 9.3. Free body diagram of the 50 lb/ft² on the infill picket of the railing. It is possible for the entire load to be carried by one picket. The distance, a, varies with the placement on the 50 lb/ft² over the picket.

\[ V_{\text{max}} \text{ when } a = 0, \]

\[ b = L - l - a = 38.5\text{in.} - 12\text{in.} - 0 = 26.5\text{in.} \]
\[ V_{\text{max}} = R_A = \frac{wl}{2L} (2b + l) = \frac{4.2\, \text{lb/} \text{in.} \times 12\, \text{in.} \times (2 \times 2.65\, \text{in.} + 12\, \text{in.})}{2 \times 38.5\, \text{in.}} = 43\, \text{lb} \]

\[ M_{\text{max}} \text{ when } a = \frac{L - l - b}{2} = \frac{38.5\, \text{in.} - 12\, \text{in.}}{2} = 13.25\, \text{in.} \]

\[ b = L - l - a = 38.5\, \text{in.} - 12\, \text{in.} - 13.25\, \text{in.} = 13.25\, \text{in.} \]

\[ R_A = \frac{wl}{2L} (2b + l) = \frac{4.2\, \text{lb/} \text{in.} \times 12\, \text{in.} \times (2 \times 13.25\, \text{in.} + 12\, \text{in.})}{2 \times 38.5\, \text{in.}} = 25\, \text{lb} \]

\[ M_{\text{max}} = R_A \left( a + \frac{R_A}{2w} \right) = 25\, \text{lb} \left( 13.25\, \text{in.} + \frac{25\, \text{lb}}{2 \times 4.2\, \text{lb/} \text{in.}} \right) = 406\, \text{in.-lb} \]

**Bending:**

\[ f_b \leq F_{b,} \]

\[ F_{b,} = F_b C_F C_D C_M = 725\, \text{psi} \times 1.5 \times 1.25 \times 1 \times 0.37 = 1,359\, \text{psi} \]

\[ S = \frac{bd^2}{6} = \frac{(1.5\, \text{in})(1.5\, \text{in.})^2}{6} = 0.5625\, \text{in.}^3 \]

\[ f_b = \frac{M}{S} = \frac{406\, \text{in.-lb}}{0.5625\, \text{in.}^3} = 721\, \text{psi} \]

\[ f_b = 721\, \text{psi} \leq F_{b,} = 1,359\, \text{psi} \quad \text{OK} \]

**Shear:**

\[ f_v \leq F_{v,} \]

\[ F_{v,} = F_v C_D C_M = 155\, \text{psi} \times 1.25 \times 0.97 = 188\, \text{psi} \]

\[ f_v = \frac{3V_{\text{max}}}{2bd} = \frac{3 \times 43\, \text{lb}}{2 \times 1.5\, \text{in.} \times 1.5\, \text{in.}} = 29\, \text{psi} \]

\[ f_v = 29\, \text{psi} \leq F_{v,} = 188\, \text{psi} \quad \text{OK} \]
9.1.2.3 Joist Span

2x8 No. 2 Southern Pine, 16 in. on-center, 40 psf Live plus 10 psf Dead

\( F_b = 1200 \text{ psi}, \quad F_V = 175 \text{ psi}, \quad S = 13.14 \text{ in.}^3, \quad l = 47.63 \text{ in.}^4 \)

Overhang: \( a = 27 \text{ in.} \), Span: \( L = 9' - 7'' = 115 \text{ in.} \)

\[
w = \frac{(LL + DL)(\text{spacing})}{(12 \text{ in./ft})^2} = \frac{(10\text{lb/ft}^2 + 50\text{lb/ft}^2) \times 16\text{in.}}{(12\text{in./ft})^2} = 5.56 \text{lb/in}
\]

\[
M_1 = \frac{w}{8L^2} (L + a)^2 (L - a)^2 = \frac{5.56\text{lb/in.*}(27\text{in.})^2}{8*(115\text{in.})^2} (115\text{in.} + 27\text{in.})^2 (115\text{in.} - 27\text{in.})^2 = 8,205 \text{ in.-lb}
\]

\[
M_2 = \frac{wa^2}{2} = \frac{5.56\text{lb/in.*}(27\text{in.})^2}{2} = 2,026 \text{ in.-lb}
\]

\[
R_1 = V_1 = \frac{w}{2L} (L^2 - a^2) = \frac{5.56\text{lb/in.}}{2*115\text{in.}} ((115\text{in.})^2 - (27\text{in.})^2) = 302\text{lb}
\]

\[
V_2 = wa = 5.56\text{lb/in.*27in.} = 150\text{lb}
\]

\[
V_3 = \frac{w}{2L} (L^2 + a^2) = \frac{5.56\text{lb/in.}}{2*115\text{in.}} ((115\text{in.})^2 + (27\text{in.})^2) = 337\text{lb}
\]

\[
R_2 = V_2 + V_3 = 150\text{lb} + 337\text{lb} = 487\text{lb}
\]

\[
M_{\text{max}} = 8,205 \text{ in.-lb, } V_{\text{max}} = 337 \text{ lb}
\]

9.1.2.3.1 Check Joist Bending

\[ f_b \leq F_b \]

\[
l_u = \frac{27 \text{in.}}{7.25 \text{in.}} = 3.7 \leq 7
\]

\[
l_e = 1.33l_u = 1.33*27\text{in.} = 36.0 \text{in.}
\]

(At Cantilever with uniform load, \( l_u/d \leq 7 \))
9. Appendix A: Sample Calculations

\[ R_b = \sqrt{\frac{1.75}{1.5^2}} = \sqrt{\frac{36in. \cdot 7.25in.}{(1.5in.)^2}} = 10.8 \]

\[ F_{ke} = \frac{K_{ke} \cdot E}{R_b^2} = \frac{0.439 \cdot 1,600,000 psi}{10.8^2} = 6,022 \text{ psi} \]

\[ F_b^* = F_b C_f C_D C_L C_M = 1,200 psi \cdot 1.0 \cdot 1.0 \cdot 1.15 \cdot 0.85 = 1,173 \text{ psi} \]

\[ \frac{F_{ke}}{F_b^*} = 6,022 \text{ psi} \cdot 5.13 \]

\[ C_L = \left( \frac{1 + F_{ke}/F_b^*}{1.9} \right) - \sqrt{\left( \frac{1 + F_{ke}/F_b^*}{1.9} \right)^2 - \frac{F_{ke}/F_b^*}{0.95}} = \left( \frac{1 + 5.13}{1.9} \right) - \sqrt{\left( \frac{1 + 5.13}{1.9} \right)^2 - (5.13)} \]

\[ = 0.99 \approx 1.0 \]

\[ F_b^* = F_b C_f C_D C_L C_M = 1,200 psi \cdot 1.0 \cdot 1.0 \cdot 1.15 \cdot 1.0 \cdot 0.85 = 1,173 \text{ psi} \]

\[ f_b = \frac{M}{S} = \frac{8205 \text{ in.} \cdot \text{ lb}}{13.14 \text{ in.}^2} = 624 \text{ psi} \]

\[ f_b = 624 \text{ psi} \leq F_b^* = 1,173 \text{ psi} \quad \text{OK} \]

9.1.2.3.2 Check Joist Shear

\[ f_v \leq F_v' \]

\[ F_v' = F_v C_D C_M = 175 psi \cdot 1.0 \cdot 0.97 = 170 psi \]

\[ f_v = \frac{3V_{max}}{2bd} = \frac{3 \cdot 337 \text{ lb}}{2 \cdot 1.5 \text{ in.} \cdot 7.25 \text{ in.}} = 46 \text{ psi} \]

\[ f_v = 46 \text{ psi} \leq F_v' = 170 \text{ psi} \quad \text{OK} \]

9.1.2.3.3 Check Deflection

\[ \Delta_{max} \leq \Delta_{allowable} \]
\[ \Delta_{allowable} = \frac{L}{360} = \frac{115\text{in.}}{360} = 0.32\text{ in.} \]

\[ w_{LL} = \frac{40 \text{psf} \times 16\text{in.}}{12\text{ ft}} = 53.3\% \times = 4.4\%_{a} \]

Midpoint of span, \( x = 57.5 \text{ in.} \)

\[ \Delta_{max} = \frac{w_{LL}x}{24EI} \left( L^{4} - 2L^{2}x^{2} + Lx^{3} - 2a^{2}L^{2} + 2a^{2}x^{2} \right) \]

\[ = \frac{4.4\%_{a} \times 57.5\text{in.}}{24 \times 1,600,000 \text{ psi} \times 47.63\text{in.}^{4} \times 115\text{in.}} * \]

\[ \left( (115\text{in.})^{4} - 2(115\text{in.})^{3} (57.5\text{in.})^{2} + (115\text{in.})(57.5\text{in.})^{3} - 2(27\text{in.})^{2} (115\text{in.})^{2} + 2(27\text{in.})^{2} (57.5\text{in.})^{2} \right) \]

\[ = 0.114 \text{ in.} \]

End of overhang, \( x = 27 \text{ in.} \)

\[ \Delta_{1} = \frac{w_{LL}x_{1}}{24EI} \left( 4a^{2}L - L^{3} + 6a^{2}x_{1} - 4a^{2}x_{1}^{2} + x_{1}^{3} \right) \]

\[ = \frac{4.4\%_{a} \times 27\text{in.}}{24 \times 1,600,000 \text{ psi} \times 47.63\text{in.}^{4} * \]

\[ \left( 4(27\text{in.})^{2} (115\text{in.}) - (115\text{in.})^{3} + 6(27\text{in.})^{2} (27\text{in.}) - 4(27\text{in.})(27\text{in.})^{2} + (27\text{in.})^{3} \right) \]

\[ = 0.07 \text{ in. upward} \]

\[ \Delta_{max} = 0.119 \text{ in.} \leq \Delta_{allowable} = 0.32 \text{ in.} \quad \text{OK} \]

9.1.2.3.4 Toenail connection of joist to ledger

16d common wire nails, assumed. Southern Pine members, \( G = 0.55 \)

\( Z = 154 \text{ lb}^{26} \)

\( Z' = Z \times C_{D} C_{M} C_{in} = 154 \text{lb} \times 1.0 \times 0.7 \times 0.83 = 89\text{lbs} \)

Load carried at each connection:

---

26 Lateral Design values of nails in single shear connections: NDS-01, Table 11N
Tributary Area = $\frac{16\text{in.} \times 115\text{in.}}{2} \times \left(\frac{1\text{ft}}{12\text{in.}}\right)^2 = 6.38\text{ ft}^2$

Design load = $(40\text{ psf} + 10\text{ psf}) \times 6.38\text{ ft}^2 = 320\text{ lb}$

Capacity = $4\text{toenails} \times \frac{89\text{lb}}{\text{toenail}} = 356\text{lb} > 320\text{lb} \quad \text{OK}$

9.1.2.3.5 Bearing Area for Joist #30

$R_2 = 487\text{ lb}$

$f_{c,\text{perp}} \leq F_{c,\text{perp}}'$

$C_p$ applies when the bearing is less than 6 in. in length and more than 3 in. from the end of the member

$C_p = \frac{l_b + 0.375}{l_b} = \frac{3\text{in.} + 0.375}{3\text{in.}} = 1.125$

$F_{c,\text{perp}}' = F_{c,\text{perp}}C_mC_b = 425\text{ psi} \times 0.67 \times 1.125 = 320\text{ psi}$

$A_b = \frac{1.5\text{in.}}{2} \times 2 \times 1.5 = 2.25\text{in.}^2$

$f_{c,\text{perp}} = \frac{R_2}{A_b} = \frac{487\text{lb}}{2.25\text{in.}^2} = 216\text{ psi}$

$f_{c,\text{perp}} = 216\text{ psi} \leq F_{c,\text{perp}}' = 320\text{ psi} \quad \text{OK}$

9.1.2.4 Posts

6x6 No. 2 Southern Pine, 55.5 in. high

$F_c = 525\text{ psi}, E = 1,200,000\text{ psi (wet service)}$

Tributary Area = 29.8 ft$^2$, 40 psf Live, 10 psf Dead.
\[
F_c^* = F_c C_D C_F C_M = 525 \text{ psi} * 1.0 * 1.0 * 1.0 = 525 \text{ psi}
\]

\[
\frac{l_c}{d} = \frac{55.5 \text{ in.}}{5.5 \text{ in.}} = 10 \leq 50 \quad \text{OK}
\]

\[
F_{cE} = \frac{K_{cE} E}{(l_c / d)^2} = \frac{0.3 * 1,200,000 \text{ psi}}{(55.5 \text{ in.} / 5.5 \text{ in.})^2} = 3,600 \text{ psi}
\]

\[
\frac{F_{cE}}{F_c} = \frac{3600 \text{ psi}}{525 \text{ psi}} = 6.86
\]

\[
C_p = \frac{1 + \left(\frac{F_{cE}}{F_c^*}\right)}{2c} = \frac{1 + \left(\frac{F_{cE}}{F_c^*}\right)}{2c} = \frac{1 + 6.86}{2 * 0.8} = \frac{1 + 6.86}{2 * 0.8} - \frac{6.86}{0.8} = 0.97
\]

\[
F_c = F_c C_D C_F C_M C_p = 525 \text{ psi} * 1.0 * 1.0 * 1.0 * 0.97 = 508 \text{ psi}
\]

\[
P = 29.8 \text{ ft}^2 * (40 \text{ psf} + 10 \text{ psf}) = 1,500 \text{ lb}
\]

\[
f_c = \frac{P}{bd} = \frac{1500 \text{ lb}}{5.5 \text{ in} * 5.5 \text{ in}} = 50 \text{ psi}
\]

\[
f_c = 50 \text{ psi} \leq F_c^* = 508 \text{ psi} \quad \text{OK}
\]
9.2 Appendix B: An Inspection Manual for Residential Wood Decks and Balconies
A Manual for the Inspection of Residential Wood Decks and Balconies

A. Introduction

A.1 Applicability

This manual is intended for use in the inspection of residential wood decks and balconies with conventional dimension lumber (2x_) framing. It is not intended to be used for homes employing engineered floor trusses or I-Joists.

A.2 Definitions

A deck, as defined in the International Residential Code for One- and Two- Family Dwellings, 2000 (IRC-2000), is “an exterior floor system supported on at least two opposing sides by an adjoining structure and/or post, piers or other independent supports.” A balcony is defined as “an exterior floor projecting from and supported by a structure without additional independent supports.”

A.3 Building Codes

Table A.1 is a summary of several model building code requirements for balconies and decks. This table is an example only. Localities may add or change requirements before adopting these building codes.
Table A.1. Load and other requirements for residential (one and two family) decks and balconies from the 1995 CABO code, the 1995 ASCE Minimum Design Loads, the 1998 Fairfax County Deck Details and the 1998 and 2000 International Code Council.

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Deck Live Load (psf)</th>
<th>Balcony Live Load (psf)</th>
<th>Dead Load (psf)*</th>
<th>Railing Load (plf)</th>
<th>Concentrated Load for railing (lb)</th>
<th>Infill Load, Over 1 ft² area (lb)</th>
<th>Max. Opening, Railing**</th>
<th>Max. Opening, triangle at stairway**</th>
<th>Height above grade at which guards are required</th>
<th>Minimum height of guards, stairway***</th>
<th>Minimum Rise of stairs required for guard</th>
<th>Minimum height of guards, stairway***</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRC and IBC, 2000</td>
<td>40</td>
<td>60 psf (less than 100 ft²)</td>
<td>100 psf</td>
<td>200</td>
<td>40</td>
<td>4&quot;</td>
<td>6&quot;</td>
<td>30&quot;</td>
<td>36&quot;</td>
<td>30&quot;</td>
<td>34&quot;</td>
<td>36&quot;</td>
</tr>
<tr>
<td>International Code Council, 1998</td>
<td>40</td>
<td>60 psf (less than 100 ft²)</td>
<td>10 psf</td>
<td>100 psf</td>
<td>200</td>
<td>4&quot;</td>
<td>6&quot;</td>
<td>30&quot;</td>
<td>36&quot;</td>
<td>30&quot;</td>
<td>34&quot;</td>
<td>36&quot;</td>
</tr>
<tr>
<td>Fairfax County, 1998</td>
<td>40</td>
<td>10</td>
<td>50</td>
<td>200</td>
<td>40</td>
<td>4&quot;</td>
<td>6&quot;</td>
<td>30&quot;</td>
<td>36&quot;</td>
<td>30&quot;</td>
<td>34&quot;</td>
<td>36&quot;</td>
</tr>
<tr>
<td>CABO, 1995</td>
<td>40</td>
<td>80 psf (less than 100 ft²)</td>
<td>100 psf</td>
<td>200</td>
<td>40</td>
<td>4&quot;</td>
<td>6&quot;</td>
<td>30&quot;</td>
<td>36&quot;</td>
<td>30&quot;</td>
<td>34&quot;</td>
<td>36&quot;</td>
</tr>
</tbody>
</table>

*Dead load is generally the weight of the materials themselves.
** Maximum Opening: Will not allow a sphere of this diameter to pass through
*** If the top rail also serves as a handrail (R-2: apartments, two-dwelling units and R-3: permanent) height must be ≥ 34” and ≤ 38” vertically from the nose of the leading tread.
B. Preparation for Inspection

B.1 General information

The inspector should collect and review general information about the deck that may contribute to the overall inspection process and final report.

B.1.1 Age of structure and building code requirements

Differences between the building code when the deck was built and current building codes should be noted and may be needed if structural repairs are required. Changes often occur in the railing requirements, including height and possibly design loads. Examples of some building code requirements are shown in Table A.1.

A special consideration in building codes is the design snow load. In some areas, the design snow loads may be greater than 1.15 times the live load design values required and would, therefore, be the controlling load in the design of the deck or balcony.

B.1.2 Size and Design

Knowing the size and type of design of the deck or balcony prior to the inspection will help in planning a thorough inspection.

B.1.3 Do Building Plans Exist?

The original plans for the deck are useful for locating key structural members, potential problem areas and any changes that have been made to the
original structure. Building plans may also specify the materials used in the deck or balcony.

**B.1.4 History**

The homeowner is a resource and might know of specific problem areas and may have tried to fix them. The maintenance history, including washing, painting, treating, damages, repairs, replacements and modifications should be recorded.

If the deck/balcony has been inspected before, the report from that inspection would be helpful in determining if problem areas are changing and how the deck is aging.

**B.2 Prepare Inspection Plan**

**B.2.1 Review original deck plans**

If plans are available, they can be used to find areas that may be affected by differences between the previous and current building codes. Plans will also give the inspector insight into areas that may have hidden members / connections or be difficult to see, such as the connection to the house.

The design should be checked for a lack of redundancy - when one element or connection fails, the entire structure can fail. Also, if the overall stability of the deck is dependent on connections and not wood-to-wood bearing, the checking of connections becomes crucial.
B.2.2 Create a systematic approach to the inspection

During the inspection, a large, clear set of plans or worksheets ready to be marked-up is useful. The inspection should normally begin with drawings or verifying plan views and elevations. This step will familiarize the inspector with the deck and allows the homeowner to be involved if they chose to be.

The inspector should record all observations carefully with all details. If it is difficult to sketch or describe a certain element, photographs are an alternative method. Pictures are also helpful in refreshing the inspectors mind while working on the analysis and can be used in the final inspection report.

B.3 Materials Checklist

The equipment and materials cited in B.3.1-3 have been found to be useful in the inspection process.

B.3.1 General

- Ladder
- Flashlight
- Measuring tape
- Fishing line
- Level
- Probing tool (pick)
- Moisture meter
- Camera
- Magnet
- Clipboard
- Worksheets or Plans
- Colored Pencils
- Small Triangle, ruler

B.3.2 Specialized Materials

- Chrome Azurol S (Mordant Blue 29): Biological Stain (Haven’t found this readily available)
- Oxalic Acid (may be available at pharmacy)
- Copper Napthenate (imitation)

**B.3.3 Tools**

- Hammer
- Socket Set
- 6” Caliper

**C. What to look for**

**C.1 Proper installation**

**C.1.1 Lumber grade and treatments**

The best way to determine the species / species group, seasoning, and grade is through the grade stamp. The stamps are usually found in areas protected from weather and near the ends of typical joist spans. A typical grade stamps is shown in Figure C.1.
Grade stamp information, abbreviations and symbols are found in the American Softwood Lumber Standard, PS-20 (American Lumber Standard Committee, 1999) and the Wood Handbook (Forest Products Laboratory, 1999; http://www.fpl.fs.fed.us/documents/FPLGTR/fplgtr113/fplgrt113.htm).

A quality mark is on lumber that has undergone preservative treatment, but usually on a tag that is attached to the lumber and removed during construction or worn away over time. This tag will contain information on the type and quantity of the preservative. The American Wood Preserver’s Association has published minimum retentions for several types of preservatives in Standard C15-02 (AWPA, 2002; http://www.awc.org/HelpOutreach/fac/C15-02.pdf).

In some cases (especially with Southern Pine), preservative treated wood has a greenish tint, however, this tint fades with time and weathering. The chemical Chrome Azurol S (Mordant Blue 29) is a biological dye that turns dark blue or black when in contact with the copper in preservative treated wood. Figure C.2 is an example of a positive result using Chrome Azurol S.
Figure C.2. This sample of Southern Pine was tested for copper using Chrome Azurol S. The result was positive, indicating the sample was pressure preservative treated.

C.1.2 Connections

The inspector should note the type, locations and edge distances of all fasteners used in the deck/balcony. The NDS-01 requires washers to be used with all bolts (Section 11.2.1.3) but does not require them to be used with lag screws even though they are recommended.

Connections commonly used and recognized by the NDS-01 are:

- Dowel Type Fasteners: nails, spikes, drift bolts, drift pins, bolts, lag screws and wood screws.
- Metal Side Plates

Other types of fasteners, such as carriage bolts, shall not be used with the design equations in the NDS-01.
C.1.3 Spacings

The inspector should note the spacing of all the fasteners and structural members. Also, any irregular spacings should be noted, as they may be a sign of construction errors.

C.1.4 Openings

Several building codes, including the IRC-2000, have specific requirements on the maximum size of openings in the guardrails and stairways, as seen in Table A.1. The maximum allowances in the IRC-2000 are that a sphere with a diameter of 4 in. shall not be able to pass through any opening, with the exception of the triangular opening between the guardrail and the stairway, where a 6 in. diameter sphere shall not be able to pass through. Another crucial area to check is the space behind open tread stairs, which is limited to the passage of a 4 in. sphere.

C.1.5 Notches

Notches are limited in size and location on bending members and are discussed in NDS-01, Section 4.4.3. Over bearings, notches must be less than 1/4 of the depth of the member. On the tension and compression faces, the depth is limited to 1/6 of the member depth and the length must be less than 1/3 of the member depth. Notches are not permitted in the middle third of spans or on the tension face of members that are greater than 3.5 in. wide.
Notches cause splits and checks that originate at the location of the notch and from kerfs at the notches. Kerfs occur when the cuts for the notch extend past the notched area.

C.1.6 Footings

Footings are dictated by the local building code. Where applicable, the depth must reach below the frost line, specified by the local building code. Where frost lines are not applicable, the IRC-2000 requires that footings reach at least 12 in. below grade. In sloped areas, at least 7 ft, horizontally, should be between the bottom of the footing and daylight.

C.2 Quality of Lumber/Connections

C.2.1 Lumber

Some problems and definitions associated with lumber are listed below. Detailed definitions are found in the American Softwood Lumber Standard, PS-20 (American Lumber Standard Committee, 1999) and the Wood Handbook (Forest Products Laboratory, 1999).

- Raised grain: rise of latewood above earlywood, but does not separate
- Shake: lengthwise separation between or through annual rings
- Shelling: late and earlywood separate
- Loose grain: separation of grain between early wood and late wood without displacement
- Delaminations in laminated lumber
- Soft spots & low spots on lumber face
- Sagging of the entire structure
- Split: separation of wood *through the piece* to opposite or adjoining sides
- Checks: separations in the wood, through or across annual rings, but not through the piece
- Warp: deviation from the plane surface
- Knot holes.

Splits are critical near fasteners. When outside the connector area and parallel to the length axis, they are non-critical.

Any decay found should be noted, as decay is a problem that will worsen. Once decay is located on an element, all strength properties associated with the species and grade are compromised. Methods to determine the presence and amount of decay in wood are presented in Section C.4.1. The pick test is described in detail in Section G.1.

Paint failure or bucking and nail pullout are problems associated with moisture content and wetting and drying cycles.

*C.2.2 Fasteners*

Rust, iron stain, corrosion and wood deterioration are problems around metal fasteners. Iron stain is often confused with mildew. A saturated Oxalic Acid solution will remove iron stain, but not mildew.

Corrosion of the fastener affects both the fastener and the wood. As the fastener corrodes, it causes the wood around it to deteriorate, which speeds up the corrosion process. As the fastener becomes smaller, the area around it becomes larger.
The tightness of the fasteners should be checked. If it is not possible to reach both sides of bolts, they may be hit with a hammer. The ring will be hollow with vibration if the connection is loose, the ring should sound solid if the connection is tight.

C.2.3 Structural Failure

Failures of the structural elements are seen as large deflections, crushing at the bearings and fractures. Load tests are required by ASCE 7-95 (ASCE, 1995) whenever the safety of the structure is questionable. However, in residential applications, it is often more economical to replace the questionable element rather than perform tests.

C.3 Exposure

The end grain of members should not be exposed to the weather. Structural elements need protection when they are in contact with the ground or masonry. Areas subject to decay are shown in the Climate Index Map in Figure C.3. A climate index of 35 or higher denotes a moderate to severe threat of decay. Untreated, naturally durable joists in these areas should be at least 18 in. away from the ground. Girders should be at least 12 in. away from the ground.
Figure C.3. Areas with high climate indexes have higher threats of decay. Index values of 35 – 70 are considered to have moderate threats of decay. Values greater than 70 are severe threats. (Forest Products Laboratory, 1999)

C.4 Decay

C.4.1 Areas to look in

Decay is most likely to occur in areas that are damp for long periods of time or have a high local humidity. These conditions also facilitate plant growth and mildew. All structural elements should be checked for decay, but the areas that need special attention are around watermarks, iron or rust stains, plant growth, mildew, joints and water trapping areas.
C.4.2 Categories

Each element in the inspection should be given a decay category based on the methods of Esyn et al. (1979). Structural elements with evidence of decay should immediately be placed in category one.

Category 1 is existing decay with severe strength loss; immediate repair and restricted use are required. Category 2 is existing decay where maintenance is needed, but limiting of use is not required. Category 3 is for areas that are conducive to decay and will require preventative maintenance. Category 4 is areas that have no decay and are likely to be safe from the threat of decay.

C.5 Insects

C.5.1 Termites

Termites do not always require wood to be in direct contact with the ground. Signs of infestation are earthen tubes that lead from the ground to the wood and piles of wings. Often, the termites will build their tunnels right below the surface of the wood.

C.5.2 Carpenter Ants

Carpenter ants are like their nests clean and piles of debris are often found below the entrance to their nest. Carpenter ants prefer softened wood that may be decayed.
C.5.3 Beetles

Beetles that infest wood are roundheaded, flatheaded, and powderpost. They lay their eggs in tunnels in the wood and oval holes (1/4 in. diameter) are left in the surface when the adults emerge. A fine powder is left under the hole.

C.5.4 Bees

Carpenter bees tunnel into softwoods in areas not exposed to direct sunlight.

D. Inspection

D.1 Plan view and elevation

D.1.1 Plan View

A scale plan view of the deck or balcony structure should be drawn for later analysis. In the drawing, railing posts, joists, beams and deck posts should all be included. Photographs of the overall structure are helpful later in the analysis and report preparation.

D.1.2 Elevations

As many elevations as necessary should be drawn. Details of the railings and stairways will be useful in the analysis. Include any bracing and a section of a single rail post detailing the connection to the deck or balcony.
D.2 Railing

D.2.1 Rail Posts

The first area on the railing to examine is the rail post. The connection to the deck or balcony should be drawn in detail. The condition of the post and the connection should be noted, giving special attention to the fasteners and notches. If possible, a fastener should be removed and its diameter, length and penetration into the main member should be measured. Any rust or corrosion on the fastener and on the wood around it should be noted. Each rail post should be checked for decay or other problems around the fasteners.

D.2.2 Infill

The height of the infill from the deck surface should be noted. Water trapping areas should be checked for decay. Large openings should be measured to see if a 4 in., 5 in., or 6 in. sphere (determined by building code) could fit through any areas of the railing.

D.3 Decking

D.3.1 Condition

The size and condition of the deck boards should be noted. The deck boards should be examined for the extent of splitting, adequate nailing, nail pull-out, and irregular spacing between the deck boards. Frequent pressure washing can cause erosion of the earlywood.
D.3.2 Stains

Any sealants, treatments or paints used on the decking should be noted. Failures or cracking of the paint could be indicative of problems with the wood below. Paint can hide critical problems in wood and fasteners. The homeowner should be informed that many problems might not be seen due to paint coverage, and the report should document all painted areas that could not be evaluated. Also, if possible, the relative importance of each painted area that was not verified as being sound should be noted in the report.

D.4 Joists

D.4.1 General

The method of attaching the joists to the ledgers and beams should be described in detail. For low structures, the joists proximity to the ground should also be noted.

D.4.2 Each Joist

The condition of each joist, including decay, questionable splits (larger than the depth of the member), and deflections should be noted on a worksheet. Also, each connection to the beams and ledgers should be checked for overall condition and compliance to the NDS.
D.5 Beams/Girders

D.5.1 Built up beams

Built-up or multi-ply beams of 2x__ lumber are common in decks. The way they are attached to each other should be noted with the nailing pattern and spacing and any material (sheathing, insulation board, siding, washers, or void space) between the two pieces. Butt joints in the beam span are not permitted.

D.5.2 General

A detail of the beam attachment to the deck posts should be drawn and the size and span of each beam should be noted.

D.5.3 Each Beam

The condition of each beam should be noted on a worksheet including the decay category, large splits and deflections. The condition of the connection to the posts should also be noted.

D.6 Footings and posts

D.6.1 Ground below deck

The ground below the deck or balcony should slope away from the building to provide proper drainage. If this is not the case, other observed means of drainage should be noted. The ground cover below the deck or balcony should be identified and noted.
D.6.2 Footings

The material of the footings should be noted and, if possible, the depth. On steep properties, the slope of the ground around the footings could affect the stability and should be noted.

D.6.3 Posts

The size, height and condition of each post should be noted, including decay categories, critical checks and splits, buckling, or twisting. If the posts are in contact with the ground, decay is an issue, the ground cover should be removed to a depth of at least 6 in. and a test for decay, such as the pick test, should be conducted to determine if there is any decay present. When the posts are not PPT, there should be a protective barrier between posts and any masonry. How the post is attached to the footing should be noted if it can be seen.

D.7 Stairways

D.7.1 General

The total rise, run and width of the stairway should be noted. The IRC-2000 requires artificial light sources that cover the entire stairway. The presence and condition of all light sources should be noted. The size of all openings should be checked for code conformance. The railings, triangular openings and areas between the risers should all be checked.
D.7.2 Railings

The railings on the stairway should be checked with the same methods as the deck/balcony railings. The presence, height and diameter of graspable handrails should be noted.

D.7.3 Risers

The condition of each riser, including decay, ground exposure and deformations should be noted. The span and attachment to the stringers should be checked and noted.

D.7.4 Stringers

The type and condition of each stringer, including decay, ground exposure and deformations should be noted. The connection of the stringers to the deck should be checked and noted.

D.8 Lateral Support / Bracing

D.8.1 Diagonal Bracing

If bracing is present, details of the connections to the deck should be noted, along with the location and condition of each section.

D.8.2 Other

If the deck or is not attached to the building, the method used for lateral support should be investigated and noted.
E. Analysis

E.1 Assumptions

All assumptions made for the analysis should be stated in the final report.

E.1.1 Lumber grade

If grade stamps are not visible, it may be reasonable to assume the species or species group of wood that was commonly used in the area of the deck or balcony at the time the structure was built. For conservative estimates, the grade assumption should be one grade below the grade that is commonly used for deck construction. When analyzing critical elements that do not reveal a grade stamp, it is recommended to use design values for the lowest grade tabulated in the NDS-01 Supplement.

E.1.2 Fasteners

It is not practical to remove and inspect all fasteners on a structure. The fastener that is removed should be one that is in an area that has the greatest exposure to weather and is typical of all connections of that type. Once one has been removed and measured, the inspector must judge, based on the overall quality of workmanship, if it is reasonable to assume other similar connections have the same properties.

In situations where fasteners cannot be removed, assumptions on the size should be based on the visible portion and according to standards such as Appendix L of NDS-01, ASME B18.2.1 (bolts and lag screws), ASME B.18.6.1 (wood screws), or ASTM F1667 (nails and spikes).
E.2 Bending Stress

Joists, railing and beams should all be checked for adequate bending strength due to the design loads required by the building codes as seen in Table A.3.1. The actual bending stress, $f_b$, must be less than the allowable design value, $F_b'$. Design values for dimension lumber and posts are found in the Supplement to the NDS-01 in Tables 4A through 4D. Methods for checking the bending stress can be found in the NDS-01, Section 3.3.

E.3 Shear Stress

Joists, railings and beams should be checked for adequate shear strength. The actual shear stress, $f_v$, must be less than the allowable design value, $F_v'$. Design values are found in the Supplement to the NDS-01 in Tables 4A through 4D. Methods for checking shear stress are in the NDS-01, Section 3.4.

E.4 Compression Parallel-to-Grain

Deck posts should be checked for adequate strength in compression parallel-to-the-grain. The actual compressive stress, $f_c$, must be less than the allowable design value, $F_c'$. Design values are found in the Supplement to the NDS-01 in Tables 4A through 4D. Methods for checking compression parallel-to-grain are in the NDS-01, Sections 3.6 and 3.7.

E.5 Compression Perpendicular-to-Grain

The compressive strength perpendicular-to-grain is usually adequate when repetitive light frame members are used. It can become questionable in areas with unusual bearing support. Any questionable joist or beam bearings
should be checked for adequate strength in compression perpendicular-to-the-grain. The actual compressive stress, $f_{c,\text{perp}}$, must be less than the allowable design value, $F_{c,\text{perp}}'$. Design values are tabulated in the Supplement to the NDS-01 in Tables 4A through 4D. Methods for checking the compression perpendicular-to-grain are in the NDS-01, Section 3.10.

E.6 Shear, Moment and Deflection

Maximum shear, moment and deflection in bending members may be determined using shear and moment diagrams or by using tables provided in many mechanics of materials textbooks. A common source for these diagrams and formulae is Volume 1 of the Manual of Steel Construction (AISC, 1994).

Deflection limits are specified in building codes and standards. The IRC-2000 limits allowable deflection by floor live loads (including decks and balconies) to the span length divided by 360 ($L/360$). The Acceptance Criteria for Deck Board Span Ratings and Guardrail Systems (ICBO, 2002) provides limits for deflections on railings. When the design load is applied at a vertical support, the horizontal deflection must be less than $h/24+L/96$ or $h/12$ where $h$ is the height of the top of the rail from the anchorage of the post to the structure and $L$ is the span length of the rail between vertical supports.

E.7 Fasteners

Design values for fasteners in withdrawal are given in the NDS-01, Tables 11.2 A-C. Adjustment factors for these values are given in NDS-01, Table
10.3.1. The withdrawal design values are given in pounds per inch of thread penetration into the main member.

The lateral capacity of the connections in the deck or balcony depends on the diameter of the fastener, the penetration of the fastener into the main member, the maximum angle of the load to the grain, and the density of both the side and main member. The root diameter of the fastener should be used in calculations of lateral capacity when the shear plane(s) contain the threads. Design values given in the NDS-01 tables are based on the full diameter of the fastener; while in practice, the shear plane often falls in the threaded portion of the fastener. Penetration into the main member is a factor with lag screws, wood screws, and nails. For lag screws in shear, the NDS-01 requires a minimum penetration of 4 times the diameter for the tabulated values to be used in design. When the penetration is between 4D and 8D, the design value must be reduced by the penetration depth divided by 8D (p/8D). Reductions for angles to the grain are given in NDS-01, Table 11.3.1B. Specific gravities of wood species and groups are given in NDS-01, Table 11.3.2A. Design values for lateral strength are determined by the yield limit equations in NDS-01, Table 11.3.1A. These equations are based on several assumptions: the faces of the two members are in contact, the edge distances are appropriate (NDS-01, Section 11.5), and the penetration limits are met.

For situations not meeting these assumptions, methods for determining the lateral strength of the connections are given in the General Dowel Equations
for Calculating Lateral Connection Values (AF&PA, 1999; http://www.awc.org/Publications/TR/index.html), also known as TR-12.

The capacities of other types of connections, such as hangers, are found in the manufacturer’s literature. These published values are based on certain installation rules and, in some cases, adjustment factors must be applied to the design values.

E.8 Building Code Conformance

The structure must be verified against all design loads in the local building code. Professional judgment may be used to determine that the element is not adequate without a formal structural analysis. For example, the strength of a decayed member does not need to be checked, but the replacement member must be adequate per the current code as it is a repair. The 2000 International Building Code states “Additions, alterations or repairs to any building or structure shall conform with the requirements of the code for new construction.”

E.9 NDS-01

The NDS-01 requirements are extensive and must be carefully checked. All applicable adjustment factors must be applied to design values. A few example of NDS-01 requirements have been discussed in this manual; some others are presented below.

Bending members and posts have a slenderness ratio limit. The slenderness ratios of bending members (NDS-01, Section 3.3.3.6) and columns (NDS-01, Section 3.7.1.4) must be less than 50.
Decks and balconies are exposed to the weather, meaning the moisture content of the lumber can exceed 19% during the lifetime of the structure. A wet service factor must be applied to all design values for structural members and connections. The specific adjustments for sawn lumber are provided in the NDS-01 Supplement with Tables 4A - D and for connections in NDS-01, Table 10.3.3.

**F. Report**

A full report of the inspection results should be presented to the homeowner as part of the inspection process. A suggested format is presented below.

**F.1 Introduction**

This section should include a brief description of the deck or balcony and the reasons given for the inspection.

**F.2 Objectives**

The objectives should be presented so both the homeowner and inspector are clear on the objectives of the inspection process to include any elements or conditions that will not be inspected, the building codes, and the standards that will be used to determine the quality of the structure.

**F.3 Methods**

A detailed description of the inspection and analysis processes should be included in the report so all parties involved will know how all conclusions were reached.
F.4 Results

In the results section, the plan view, elevations and results of the analysis should be shown with drawings clarifying any hard to describe areas.

F.5 Conclusions

The conclusion should contain all findings and recommendations. Any features of the structure that could not be viewed or were hidden should be documented. When discussing the adequacy of elements, all assumptions should be listed. If structural deficiencies are found, the recommendations for repair or replacement should be included. The conformance of the structure with the local building codes and the NDS-01 should be used to determine and document structural deficiencies.

F.6 Calculations

All calculations or sample calculations deemed valuable to the report should be included.
G. Appendix

The information contained in this appendix is a supplement to the manual. This appendix contains information on the “pick test” for detecting wood decay, a discussion on deck-to-house attachment issues, a full sample report and a list of references.

G.1 Pick Test

G.1.1 Introduction

From a structural engineer’s point of view, the design and construction is only valid for future service if the material is in its original condition, free of degradation. There are several factors that degrade the state of the lumber used, including fungal decay. The “pick test,” described below, is based on toughness and has been proven to detect decay with as little as 5 to 10% weight loss (Wilcox, 1983).

G.1.2 Objective

To introduce and demonstrate the use of the “pick test” as a tool for evaluating the condition of lumber and timbers that may contain early stages of fungal decay.

G.1.3 Decay Detection using the Pick Test

Fungal decay is common in areas near fasteners, joints, checks, end grain, paint discoloration and where lumber and timbers are near or in contact with soil. The "pick test" uses an ice-pick tool to penetrate the wood surface.
Other tools such as an awl or even a small screw-driver can also be used. After penetrating the wood, the tool is rotated to pry a splinter, parallel to the grain, away from the surface. The appearance of the broken splinter is used to determine if the piece is decayed. Since different species have different densities and all lumber is affected by its environment, trying the pick test in an area where the wood is known to be sound would be a way to determine a “control” for the rest of the inspection. The test should be conducted in a late-wood zone (the darker, thinner growth rings), although the test also may work in early wood zones. The testing should begin in areas that are conducive to fungal decay, noting how much pressure is required to penetrate the surface. The depth should be about 1/4 in. A small amount of the surface wood should be pried out and compared to the results of the non-decayed wood.

Wilcox (1983) identified three distinct modes of failure for decayed and non-decayed wood. Non-decayed wood will generally fail with either a fibrous failure or a splintering break as shown in Figure G.1 and G.2. Decayed wood will have a brash, brittle failure with breaks directly over the tool. Very few splinters, if any, will appear and the break will be across the grain as shown in Figures G.2 and G.4. Figure G.1 and G.2 were taken in a salvaged Douglas Fir log yard. In the Figure G.1 and G.2 examples, the wood is weathered, and to the inexperienced eye they look the same.
Figure G.1. The sound wood broke in a solid piece, and far from the tool. It was difficult to penetrate deeply. One end did not break at all. The wood under the splinter is intact and looks new.

Figure G.2. The decayed wood broke easily; the break is across the grain with no splinters.

In a fibrous failure, the splinters are long and separate out of the surface far from the tool as shown in Figure G.3 (Virgin Douglas Fir). A splintering break typically occurs directly over the tool with numerous splinters. It is possible that the wood is very dense and in such good condition that penetration is difficult. Also noticeable with sound wood is the noise associated with the break. In non-
decayed wood, the sound will be as expected when wood breaks. However, with
decayed wood, the breaking noise will not be as loud, or there may be almost no
audible sound.
G.1.4 Conclusions

The pick test is a simple, subjective test that is useful to detect decay near the surfaces of wood members. With experience, the user will be able to identify fungal decay more readily and detect the subtle differences between the decayed and non-decayed areas. For inspections where only knowledge of the presence of decay is needed, such as residential decks, the pick test is useful. For the case of a residential deck or balcony, we recommend wooden members be replaced if any decay is detected. If the lumber is not pressure preservative
treated (PPT), this fact should be considered when making the decision to replace the elements.

G.2 Deck Attachment

G.2.1 Introduction

Problems with the attachment of residential decks and balconies to houses are common. The purpose of this section is to analyze a common connection detail between the ledger board and band joist and to offer alternate details that will meet accepted structural design criteria for wood construction that would likely be imposed by a professional engineer.

G.2.2 Typical Deck Details


The building code load requirements for residential decks are 40 psf live load and a dead load that accounts for the weight of the materials (about 10 psf). The live load required for a residential balcony is generally 60 psf. Unfortunately for the professional deck designer, the codes do not specify a lateral load requirement for lateral stability of the decking support system (joists, beams, and posts).

As an alternate to the details shown in many deck books and magazines, Figure G.5 is a conceptual connection detail between the band joist and ledger board. In this connection, the reaction force of the deck joist is transmitted
directly to the band joist by lag screws or bolts acting in shear. Note that the band joist and ledger board are in direct contact, separated only by the flashing. If insulation board is between the members, the strength of the lag (or bolt) connections is significantly reduced. If structural sheathing is between the two members, the strength is reduced to a lesser extent.
The flashing and preservative pressure treatment (PPT) band joist are the result of field studies of existing decks by Mr. Roger Robertson of the Chesterfield County (VA) Building Department. His field studies revealed decay of untreated perimeter bands and decay of the interior floor joist around the nails. Therefore, it is recommended that the band joist at the deck-house interface be PPT or equivalent and that flashing be installed between the band and the ledger board. He also observed the corrosion of aluminum flashing within five years when in contact with CCA treated lumber, therefore no longer preventing water from entering the structure. If aluminum is used, it is recommended that it be coated to prevent corrosion. One possible option is draping 15# felt paper over the flashing to separate the aluminum from the CCA lumber.
G.2.3 Lag Screw Shear Values

National Design Specification for Wood Construction (NDS-97) tables cannot be used to calculate the allowable shear capacity of a 1/2 in. lag connection for two pieces of 2x_ material because the NDS tables are based on a penetration 8D (4 in. for 1/2 in. lag) into the main member (band) and a minimum of 4D (2 in.) for reduced design values. Thus, the question is: How much shear load can a 1/2 in. lag screw carry in a ledger/band application?

Because the point of a lag screw is not effective in load transfer, a 1/2”x3.5” lag screw was assumed to connect two pieces of 2x_ material with no sheathing or insulation between the two members. Assuming the ledger board was 2x_ Southern Pine (SP) and the band joist was 2x_ SPF, formulae provisions of the NDS-97 were used to calculate the allowable shear load per screw. The result was 180 lb per lag screw without any adjustment for the fact that the SP could have a moisture content greater than 19% which, theoretically, lessens the shear value. Using the 180 lb/screw allowable shear value, Table G.2.1 was generated to determine the screw spacing for various joist spans.
Table G.1. Required spacing* of 1/2"x3.5" lag screw connecting SP ledger to SPF band joist for residential deck joist spans (loaded by 40 psf live plus 10 psf dead load).

<table>
<thead>
<tr>
<th>Joist Span (ft)</th>
<th>6</th>
<th>8</th>
<th>10</th>
<th>12</th>
<th>14</th>
<th>16</th>
<th>18</th>
</tr>
</thead>
<tbody>
<tr>
<td>On-Center Spacing (in.)</td>
<td>14.4</td>
<td>10.8</td>
<td>8.6</td>
<td>7.2</td>
<td>6.2</td>
<td>5.4</td>
<td>4.8</td>
</tr>
</tbody>
</table>

*Values are based on the root diameter of lag screws purchased at a local building supply store.

At first glance, the lag screw spacings in Table G.1 appear to be overly conservative. Without doing a lag screw survey, common lag screw spacings for deck attachments are two to five times greater than the required spacings in Table G.2.1. The spacing requirements in this table verses common field practice was noted by Christopher DeBlois, P. E., in *Practical Engineering* (JLC, March 1996): “What I am sure of, though, is that almost all the decks that I do inspect don’t have enough bolts connecting the deck band joist to the house.” So, the question is, “Why don’t residential deck-to-house connections fail on a routine basis?”

G.2.3.1 Reason Number 1:

Assuming a 12’x18’ residential deck, a 40 psf live load is equivalent to 58 people based on an average weight of 150 lb per person. In reality, this many people are not likely to gather at one time on most 12’x18’ residential decks during the entire life span. (However, it is possible and thus the code contains the 40,psf live load requirement.)

G.2.3.2 Reason Number 2

The required spacing for the lag screws in Table G.1 is based on an assumed uniform loading of the entire deck. However, large groups of people
don’t normally sit right next to the house. Instead of the uniform loading depicted in Figure G.6a, the occupancy loads on the deck are probably greater on the outside section (Figure G.6b) and thus the outer supports are more heavily loaded compared to the house side.
Figure G.6. (a) Building codes require decks to be designed to carry a uniformly distributed load over the entire surface. Half of the assumed uniform load is carried by the deck-to-house connection; the other half is carried by the posts. (b) People tend to gather near the railings of the deck, and less load is likely carried by the deck-to-house connection.

G.2.3.3 Reason Number 3

Lag screw allowable shear values are based on code approved engineering standards. The safety factor on the allowable design value can be as high as 5.0 when tested in a laboratory. Thus, a perfectly installed 1/2 in. lag screw installed in a band joist/ledger application will typically carry a lot more than 180 lb of load before the connection ruptures. However, the safety factor should not be encroached upon in design, as the purpose of a safety factor is to account for the many uncertainties of construction, service conditions, and design. For one example of construction uncertainty, it is very easy to drill a lead hole for the threads that is too large, thus compromising the strength of the connection. For a service example, referring to Figure G.1, when the band joist is not PPT or untreated heartwood of the PPT ledger is exposed to water that migrates along the length of the screw, decay around the lag screw can reduce
the connection capacity. For an example of design uncertainty, when two screws are placed in a row in PPT material that is wet and connected to “dry” lumber (band joist), the PPT lumber can split when it dries and shrinks perpendicular-to-grain. (This case is addressed in the NDS-97 and the NDS requires a 60% reduction in lag screw shear values.) In most cases, lag screws are installed with good workmanship, the band joist and ledger lumber are not decayed, and the PPT lumber doesn’t split due to two screws being aligned in a row, thus the safety factor on the screws prevent failures when the decks are lightly loaded in-service, probably 20 psf or less.

G.2.4 Engineered Decks

Many residential decks are not engineered per national design standards, yet an inspector may be called upon to verify that a deck (or balcony) is safe. In this section a conceptual detail is offered that will accommodate in-service inspection, utilizes more efficient connections, and has elements of structural redundancy.

Bearing reaction points that utilize only mechanical fasteners (bolts, screws, nails) are inherently inefficient compared to wood-to-wood bearing. The use of wood-to-wood bearing for vertical support is more efficient, relying on the perpendicular-to-grain compression strength of the lumber. In design, connections are at least as important as properly sized members, yet often in practice they are not given the same attention.

From an engineering and inspection point of view, a self-supporting deck is easier to inspect and to verify that the deck is safe for future service because
all elements (except the footers) are exposed. Figure G.2.3 shows one possible detail for this idea. The post is located next to the house and notched to receive the beams. The ends of the posts placed in the ground should not be cut, as it would expose untreated heartwood. Southern pine heartwood, as well as the heartwood of other softwood species, does not accept the penetration of the CCA chemical treatment, thus only the end surface contains the chemical. The heartwood of “naturally durable wood” is recognized by the model building codes as being equivalent to PPT, but it would certainly be more expensive than a PPT softwood such as southern pine.

For a longer post life, the use of 0.60 lb/ft³ (minimum) preservative retention is recommended by AWPA Standard C15-00 for “Sawn Building Poles and posts as structural members.” Many post-frame builders use the 0.60 lb/ft³ treated post product and they may be a local source of this material. (http://www.postframe.org/locate.htm). The 6x6 posts that have been seen in the retail building supply centers are treated to the 0.40 lb/ft³ standard. All treated posts should bear the mark or tag of a 3rd party inspection agency for the pressure treatment. Another post option is PPT Parallam® PSL, and engineered lumber product made by TrusJoist. The lowest CCA minimum retention shown at their website is 0.60 lb/ft³ (http://www.tjm.com/PDFFiles/3425.pdf). The specific type of treatment should be considered by the deck designer in view of the fact that CCA is scheduled to be phased out for some residential applications beginning in December 2003 (http://www.preservedwood.com/news/020212ccatrans.html).
Trash, vegetation, or construction debris should not be placed in the post hole as it will compromise the lateral resistance of the embedded post section. It is suggested that the post be hole be back-filled with an 80 lb bag of concrete mix, followed by well-compacted (at most 8” before tamping) native soil or sand and gravel mixture. The concrete above the footing pad will stabilize the bottom of the post in the unlikely event that the footing pad should rotate in-service. The size of the post footing pad and depth of post embedment for a design should be determined by the deck designer for the local climate (frost line) and soil strength, and local building code if applicable.

The deck joists are stacked on the built-up beams. This approach minimizes the reliance on mechanical connections to resist gravity loads (40 psf or 60 psf plus dead load). For lateral support, which is extremely important and not quantitatively addressed by the building codes (as stated earlier), galvanized thru bolts or rods are used to connect the post to the concrete foundation in two places, at the top of the post and about 12 in. above grade. This connection avoids penetrating the band joist, preventing the potential decay problems described earlier.
Figure G.7. In this deck detail, wood-to-wood bearing or wood-to-concrete bearing is relied upon for vertical load transfer, rather than connections. The attachment to the house is for lateral support only. Hollow masonry must be reinforced by rebar and concrete.

The detail in Figure G.7 demonstrates the design concept of redundancy. In this detail, the thru bolt prevents “sideway” of the deck that would occur if only the outside posts were embedded a minimum of 3’-6” in the ground. However, in the unlikely event that the thru bolts should fail due to corrosion or any reason, the embedded PPT 6x6 posts would prevent a lateral collapse of the entire deck. Thus, the detail in Figure G.7 has a “fail safe” feature, or is redundant, in that possible failure of one element (the thru bolts) should not cause massive collapse of the entire deck. It is possible for the deck without the thru bolts to move laterally an inch or more, but this amount of movement should not result in collapse or personal injury.
G.2.5 Inspection

When an engineer or home inspection professional is engaged to verify the adequacy of a deck, their job is to establish that the deck being inspected is unequivocally safe for future use. A statement by the engineer that the deck is “probably safe” is not sufficient. A self-supporting deck can be verified for with ease at a later date, decades after the original construction.

G.2.6 Conclusion

Two approaches to deck support at the house interface have been reviewed. Ledger board attachment is very common, but it is difficult to inspect for code conformance and to verify that the elements have not been degraded in-service. Since decks are subjected to both code specified gravity type loads (40 psf plus dead) and unspecified lateral loads, a conceptual detail was proposed in Figure G.7 that addresses both loading directions—vertical and horizontal. The detail has redundancy features whereby the possible failure of one element will not automatically produce or permit collapse of the entire structure. The detail also eliminates the needed to penetrate the house siding, sheathing, and band joist, thus eliminating the decay hazard for the house elements.

Deck-to-house or balcony-to-house connection details that accommodate professional inspection of in-service decks are also good details for homeowners. The owner and contractor, after careful consideration, are left to choose between the two general deck-to-house attachment methods.
G.3 Sample Report

G.3.1 Introduction

A residential deck built in 1988 was selected for this inspection. The full history of this deck was known before the inspection took place and the homeowner was willing to have parts of the deck temporarily removed. A full inspection was conducted and the structural elements were checked for conformance with the NDS-01 and the IRC-2000, assumed to be applicable for this inspection.

G.3.2 Objectives

1. To thoroughly examine a residential deck, with full documentation and report.
2. To gain insight into the inspection process.
3. To determine if the inspected deck is in accordance with the 2000 International Residential Code for one-and two-family dwellings and the 2001 National Design Specification for Wood Construction.

G.3.3 Materials and Methods

G.3.3.1 Preparation

The homeowner was questioned about the history of the deck, including age, the presence of plans and any repairs that had been made.
G.3.3.2 Plan View and Typical Sections

The plan view of the deck was created first, as a way for the inspector to become familiar with the deck layout and identify areas that may need closer scrutiny. All railing posts, deck posts, beams, joists, stairways and major dimensions were shown on the drawings.

A typical railing section was drawn for future analyses. It included details of the railing posts, infill, and connections. The stairway detail included risers, railing, and stringers.

G.3.3.3 Railing

Information gathered on the deck railing was the height of the railing above the deck, materials, how the railing was attached to the deck (including hardware) and a thorough inspection of each rail post and the infill areas between the posts. Components were checked from both the deck side and from the ground side (when possible). The height was measured from the top of the deck boards to the top of the cap rail. The rail posts were checked for decay, insect holes, splits and construction errors. The connection of each rail post to the deck was also assessed. Infill pickets were checked for loose elements and their connection to the deck. Any findings were documented in tables.

For the structural analysis, a typical 16 in. section of the infill was selected and photographed as well as measured. One lag screw and one nail were removed for examination, and then replaced. For practicality, all other connections of the same type were assumed to be in the same condition based on a comparison of the visible parts of the hardware.
G.3.3.4 Decking

The deck board material, size, and treatments were all recorded. The condition of the deck boards was noted, as well as the type of connection to the joists. A level was used to check that the structure was level. The nails were checked for pullout and actual attachment to the joists.

G.3.3.5 Joists

Grade stamps were located to document the species and grade of the joists. Their attachments to the ledger board, beam and perimeter joists were also noted. The spans, sizes and overhangs were all recorded in a table. Also recorded was the overall condition of each joist and the condition of all connections.

G.3.3.6 Beams/Girders

Beams were checked for species and grade. The type of attachment to the deck posts was noted. Built up beams were examined for the nailing pattern and edge distances for the nails. Spans, sizes and overall condition of each beam span were recorded in a table. The tightness of the connections, or presence of gaps, was also observed and noted.

G.3.3.7 Posts

The slope of the ground under the deck was noted, as well as the condition of the ground. Post species, grade and treatment were all recorded. The sizes, heights (from ground to the beam) and overall conditions the posts were logged into a table. At the foot of one typical post, the soil was removed to
a 6 in. depth and the post was checked (using the pick test described in Section G.1) for decay.

G.3.3.8 Stairways

The stringer type, presence of handrails, railing height, dimensions and materials of the stairway were all recorded. Dimensions included the total rise, total run, tread width, each rise and nosing. Each riser was examined for decay and other hazards. The riser details were recorded in a table. Other stairways on the deck were also examined and included in the table.

The stringers were each checked and their condition was also recorded.

G.3.3.9 Lateral Support/Bracing

Lateral support for the deck was provided by the attachment to the house and the embedment of the 6x6 posts. Depth of embedment was not determined.

G.3.3.10 Attachment at Ledger

The species, grade, size and treatment of the ledger board were all recorded. Areas around the ledger were all examined closely to determine how the ledger was attached to the house and what materials were present between the ledger and the band joist. Photographs were taken of the material and a magnet was used to determine if the flashing material was galvanized steel or aluminum.

From the inside of the house, the material of the band joist and the penetration of the lag screws were determined. The spacing and pattern of the lag screws were noted. One lag screw was removed and the condition and
measurements were noted (especially at the shear plane). The wood fibers surrounding the hole after the lag screw was removed were also inspected for decay. After photographing, the lag screw was replaced. Other lag screws were assumed to be in the same condition as the typical lag screw based on the size and condition of the heads.

G.3.3.11 Other

The condition of the decorative trim around the deck was also noted.

All structural elements were assigned a decay category based on inspection methods described by Eslyn et al. (1979). Category 1 is existing decay with severe strength loss, requiring immediate repair and restricted use. Category 2 is existing decay without any limitations on use, but maintenance is needed. Category 3 is conducive to decay and preventative maintenance is needed in that area. Category 4 is no decay present.

Any areas that could not be seen without taking the deck apart were noted so the inspector could disclaim responsibility for concealed parts not possible to inspect, and at the same time, communicate to the owner (client) the limitations of a non-evasive inspection.

G.3.4 Results

G.3.4.1 Preparation

The homeowner informed the inspector that the deck was constructed in 1988 with the new construction of the house by a local building contractor. Since then, the homeowner has added lag screws at a few areas that seemed weak
and at splits in the rail posts. He had not checked the tightness of the bolts or lag screws since the deck was built.

G.3.4.2 Plan view and typical sections

The deck had three main sections at different levels. The plan view with locations of beams, joists, deck posts and rail posts can be found in Section G.3.6.2. A typical rail section and stairway section are also located in this section.

G.3.4.3 Railing

The railing measured 36 in. above the deck boards. The infill pickets were nominal 2x2 Western Cedar posts 8 in. on-center attached to a 2x4 top rail and the perimeter joist. The rail posts were attached to the top rail by toenailing; the infill pickets were attached to the top rail with one nail each. The cap rail was 2x6 and protected all railing posts from end grain exposure. Rail posts were 2x4 Western Cedar attached to the perimeter joist by notching the posts (1-3/4 in. by 11-1/2 in.) and using nominal 1/4”x3” lag screws and 16d annular threaded nails in two different configurations, shown in Figure G.8.
One lag screw was removed and it had a 0.234 in. shank diameter and 0.175 in. root diameter. The effective length of the lag screw was 2.75 in. Discoloration was seen in the shear plane. The nail was 16d annular threaded with a shank diameter of 0.150 in. The root diameter was 0.140 in. at the unaffected areas and 0.139 in. at the discolored area. Photographs of the nail and lag screw are shown in Figures G.9 and G.10.
Figure G.9. The nail removed from a rail post (a) before it was removed and (b) when it was measured.

Figure G.10. The lag screw that was removed from the rail post. There is noticeable discoloration at the screw head and the interface between the post and the perimeter joist.
Tables G.2 and G.3 give the results of the inspection process on the rail posts and infill sections. The type of connection is identified as A or B with A being two lag screws and one nail, and B being two nails and one lag screw. The NDS-01 specifies allowable notch depth in bending members at the bearing as less than 1/4 the depth of the member. The notch depth in the rail posts is 1/2 of the depth, and the rail posts are not in conformance with the NDS-01. Splits at the notches were a concern and were measured. Splits and kerfs are shown in Figure G.11.
Figure G.11. (a) The kerf on railpost #12 (b) The split in railpost #14 and the lag screw added by the homeowner.
The section of railing selected for the structural analysis unit was 16 in. in width and included two infill posts as shown in Figure G.12. Calculations (shown in Section G.3.6.1.2) were performed to determine the strength of the railing in this area. The IRC-2000 states that a railing must withstand a concentrated load of 200 lb in any direction along the top of the rail. Other building codes required that the railing resist a distributed force of 50 lb/ft and the infill must be able to carry a 50 lb load over 1 ft$^2$. 
Using the NDS-01, a lag screw in the picket safely resists 115 lb in withdrawal and 95 lb in shear. The allowable withdrawal strength of the nail (assuming hardened steel) is 28 lb and the allowable lateral resistance value (shear) is 99 lb. The 50 lb/ft (4.2 lb/in) distributed load is distributed by the cap rail to the infill posts, placed 8 in. on center. When a force is exerted outward, the top fastener of each infill post must be able to resist 252 lb. When the force is downward, the fastener must resist 34 lb. in shear. The railing is not adequate to hold the 50 lb/ft load when it is applied horizontally and outward.

The cap rail also distributes the 200 lb concentrated force. When a force of about 50 lb was applied by the hand of an inspection team member horizontally outward on the cap rail, the railing deflected more than 1 in. The railing was stiffer when a vertical load and an inward horizontal load was applied.
It was then determined that the railing could not safely withstand the 200 lb concentrated load in any direction as required by the IRC-2000 building code.

Within the infill area, a 50 lb force over 1 ft$^2$ causes a maximum of 50 lb on 1 ft of one post. Calculations (Section G.3.6.1.2) show that the infill pickets can adequately carry this load.

G.3.4.4 Decking

The decking was 5/4x6 Western Cedar attached to the joists using two 2.5 in. annular threaded nails. A small amount of iron stain was noticed around the nail heads. Some nails were missing on a few deck boards. In one area, nails were missing, but the deck boards were well secured to the joists by other nails. A level was used to show that there was no detectable deflection or sagging of the structure. Decay was found in a few deck boards, as shown in Figure G.13, where the end grain was exposed to weather. It was limited to a small section of sapwood. Mildew was present on the deck and a few knotholes were found. On the underside of the deck boards, a white substance was seen, probably mold.
G.3.4.5 Joists

The joists were 2x8 No. 2 Southern Pine. They were attached to the ledger with four toenails and rested on a 2x2 support. The 2x2s were nailed at 8 in. on center. Nail size was not determined as the 2x2 support was not relied upon in any engineering calculations. The 2x2’s were probably not stress rated material and they were not included in the analysis of the connection. Assuming the toenails were 16d common nails, each can support 89 lb laterally and the connection must support 320 lb. Joists were stacked over the beam and toenailed to the beam. The perimeter joist was attached to the joists with alternating TECO-11-GRIP type 28 hangers and nails. Where the joists met the beams at a diagonal, they were nailed, not stacked.

Each joist was checked over and noted in Table G.4. One-half of joist No. 30 was supported by beam No. 4 as shown in Figure G.14.

Figure G.13. Sapwood decay was present at the end-grain of deck boards.
Figure G.14. One half of joist No.30 was supported by the beam, which was probably a construction error and not intended.

Using calculations, as shown in Section G.3.6.1.3, the spans of the joists were checked in shear, bending and deflection. All joists were found to be adequate for carrying loads as required by code, including joist No. 30.

G.3.4.6 Beams/girders

Built-up beams (beam spans 1 through 4) were 2-2x12 No. 2 Southern Pine nailed together with two nails roughly spaced at 2 ft on-center with a single nail located near the middle of the space. The posts were notched for the beams and attached with two 1/2 in. machine bolts. The beams were notched at the posts (no more than 1/4 in.) to make up for the top of the posts not being level.
during installation. Other beams were 2x12 No. 1 Western Cedar and 2x8 No. 2 Southern Pine. Figure G.15 shows how the carriage bolts were rusted around the edges and crushed the wood around them.
Specifics of each beam are shown in Table G.5. Beams were checked using methods from NDS-01 in bending shear and deflection using the same methods as the joists. Beam No. 10 failed in the bending stress check. However, beam No. 10 is paired with a No. 1 2x12 Western Cedar perimeter board, nailed with three 16d threaded nails 24 in. on center. With this added strength, the beam is adequate.

G.3.4.7 Posts

The ground below the deck sloped sufficiently away from the house and was dry at the time of inspection. All posts were No. 2 Southern Pine, CCA pressure-preservative-treated. The amount of treatment could not be determined, but was deemed to be effective after a pick test. The pick test was
performed 6 in. below the ground surface at post No. 5 and revealed no evidence of decay as shown in Figure G.16.
Heights and conditions of posts are shown in Table G.6. Each post was checked for adequacy according to the NDS-01 requirements and sample calculations are shown in Section G.3.6.1.4.

G.3.4.8 Stairways

Solid stringers (2x12 Cedar) made up the outside of the stairways with a cut stinger in the center. The seven risers were 36.5 in. wide with an 11.25 in. tread depth, 7.5 in. rise and 1.5 in. nose. The total rise of the stairs was 60 in. and the total run was 6'-3". Each riser was made with two 2x6s with a 1/4 in. space between them. Risers were placed into a 3/4 in. notch in the solid stringers. Conditions of each riser and the stringers are shown in Table G.7.

Each riser was checked and determined to be in good condition. Some white mold was found on the underside of the risers, near the stringers. One
riser had a 1.75 in. diameter knothole that could cause a fall accident for a person wearing “high heels”. Also, artificial lighting was not present around the stairway as required by the IRC-2000.

Two other sets of two steps were also checked and found to be code conforming.

G.3.4.9 Lateral Support/Bracing

Lateral support for the deck was provided by the attachment of the ledger board to the house frame.

G.3.4.10 Attachment at Ledger

The ledger board was a PPT 2x10 No. 2 Southern Pine. It was attached to the house framing with 1/2”x4” nominal lag screws placed 24 in. on center. At the ends and butt joints, two lag screws were present. In all other places the lag screws were placed alternating top and bottom. Aluminum flashing and 1/2 in. insulation were placed between the ledger and the band joist, as shown in Figure G.17. From the inside of the house, the lag screws were found to penetrate fully into the band joist with the pointed end coming completely through the joist. The band joist was untreated Spruce-Pine-Fir.
Figure G.17. Material between the ledger and the band joist was observed at a vent. From right to left the materials are the band joist, 1/2" insulation, ledger and 2x2 support for joists.

One lag screw was removed and measured. The shank diameter was 0.481 in. and the root diameter was 0.372 in. The lag screw and the surrounding wood were in excellent condition. The ledger board could not be removed and, as a result, the condition of the aluminum flashing is unknown.

Figure G.18 shows the lag screw as viewed from inside the house and once it was removed from the ledger.
As constructed, each lag screw must support 480 lb in shear or lateral loading. The penetration of the lag screw into the band joist was the full 1.5 in., which exceeds the 4D minimum (4 x 0.372 in. = 1.49 in.) required for the use of the NDS-01 tables. The lateral strength of the lag screw was found using the yield equations in TR-12 (AF&PA, 1999). The analysis included the 1/2 in. gap (for insulation) between the ledger and the band joist. The design value for a 1/2 in. lag screw in this case was 120 lb.
G.3.4.11 Other

The decorative cedar trim around the deck was found to be pulling out in some areas. One area, in place to protect a post from end-grain exposure, had decay present.

G.3.5 Conclusion

G.3.5.1 Conformance with NDS-01

Structural elements were checked by the methods described in the NDS-01. The structural checks included bending stress, shear stress, deflection and axial compression stress in posts. All members were adequate, except beam No.10, which was discussed in Section G.3.4.6. The lag screws in the ledger are not adequate to support the gravity design loads. The lag screws and nails in the railing are also insufficient.

Carriage bolts, used in connecting beams to posts, are not recognized by the NDS. Section 11.1.2.3 of the NDS-01 requires washers on both sides of the connection. The notches on the railing posts are greater than the allowable sizes as described in NDS-01 Section 5.4.3.

G.3.5.2 Code conformance per the IRC-2000

The 200 lb concentrated load requirement of the IRC-2000 could not be proven for the railing construction. Also, the 50 lb/ft railing load could not be backed up by calculations for the construction. The 50 lb/ft load is not required by the IRC-2000, but it was evaluated for demonstration purposes. The infill pickets were placed 8 in. on center, leaving 6-1/2 in. open in between them,
which is greater than the 4 in. maximum as required by the IRC-2000. At the stairway, the railing was 31 in. above the riser at some points, which is less than the minimum 36 in. The openings behind the stairs were greater than 4 in. and no blocking was provided. Also, at the stairway, an artificial light source was not present, thus the stairway is not code conforming.

G.3.5.3 Other concerns

Insect holes were found on some deck elements, but infestations were not a problem.

Small knotholes in the deck boards could cause a person to trip, and the hole on stairway riser No. 5 (from the bottom) was large enough to be a safety hazard.

Splits in the rail posts are a problem that could “grow with time. The ability of those posts to withstand the loads dictated by building codes is less than predicted by calculations that assume all elements are in good condition.
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G.3.6 Appendix to Sample Report

G.3.6.1 Sample Calculations

G.3.6.1.1 Nomenclature for Sample Calculations

\[ b = \text{breadth of rectangular member, in.} \]
\[ C_b = \text{bearing area factor}^1 \]
\[ C_d = \text{penetration depth factor}^2 \]
\[ C_D = \text{load duration factor}^3 \]
\[ C_F = \text{size factor}^4 \]
\[ C_L = \text{beam stability factor}^5 \]
\[ C_M = \text{wet service factor}^6 \]
\[ C_p = \text{column stability factor}^7 \]
\[ C_r = \text{repetitive member factor}^8 \]
\[ C_{tn} = \text{toenail factor}^9 \]
\[ d = \text{depth of rectangular member, in.} \]
\[ D_r = \text{root diameter, in.} \]
\[ E = \text{modulus of elasticity, psi} \]
\[ f_b = \text{bending stress, psi} \]
\[ f_c = \text{compressive stress parallel-to-grain, psi} \]
\[ f_{c,\text{perp}} = \text{compressive strength perpendicular-to-grain, psi} \]
\[ f_v = \text{shear stress parallel-to-grain, psi} \]
\[ F_{b, b'} = \text{tabulated and allowable bending design value}^{10}, \text{psi} \]
\[ F_{bE} = \text{critical buckling design value for bending members, psi} \]
\[ F_{c, c'} = \text{tabulated and allowable compression design value parallel-to-grain}^{11}, \text{psi} \]
\[ F_{c,\text{perp}, c_{\text{perp}}'} = \text{tabulated and allowable compressive design value perpendicular-to-grain}^{12}, \text{psi} \]
\[ F_{cE} = \text{critical buckling design value for compression members, psi} \]
\[ F_v, F_v' = \text{tabulated and allowable shear design value}^{13}, \text{psi} \]

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1 Bearing Area Factor: NDS-01, Section 3.10.4
2 Penetration Depth Factor: NDS-01, Table 11J footnote 3.
3 Load Duration Factor: NDS-01, Table 2.3.2
4 Size Factor: NDS-01 Supplement Table 4A
5 Beam Stability Factor: NDS-01, Section 3.3.3
6 Wet Service Factor: NDS-01, Table 10.3.3
7 Column Stability Factor: NDS-01, Section 3.7.1
8 Repetitive member factor: NDS-01 Supplement, Table 4A
9 Toenail factor: NDS-01 Section 11.5.4
10 Bending: NDS-01 Supplement Table 4A and 4B
11 Compression: NDS-01 Supplement Table 4A and 4B
12 Compression perpendicular-to-grain: NDS-01 Supplement Table 4A and 4B
13 Shear: NDS-01 Supplement Table 4A and 4B
G.3.6.1.2 Railings

G.3.6.1.2.1 Allowable loads

16d Threaded Nail in Withdrawal

\[ D_r = 0.139 \text{ in., Effective Length} = 3.3 \text{ in.} \]

\[ G = 0.36 \]

\[ W = 1380G^{\frac{3}{2}}D = 1380 \times 0.36^{\frac{3}{2}} \times 0.139 = 14.9 \text{ lb/in} \]

\[ W' = WC_{M} = 14.9 \times 1.25 \times 1.0 = 18.6 \text{ lb/in} \]

---

14 Specific Gravity: NDS-01, Table 11.3.
15 Moment of Inertia: NDS-01 Supplement, Table 1B
16 Euler buckling coefficient, \( K_{BE} = 0.439 \) for visually graded lumber: NDS-01 Section 3.3.3
17 Euler buckling coefficient, \( K_{CE} = 0.3 \) for visually graded lumber: NDS-01 Section 3.7.1
18 Effective Length for a Beam: NDS-01, Table 3.3.3. For a post: NDS-01 Section 3.7.1.2 and Appendix G
19 Section Modulus: NDS-01 Supplement, Table 1B
20 Withdrawal Design Value: NDS-01, Section 11.2.3, eq 11.2-3
21 Adjustment Factors: NDS-01, Table 10.3.1
\[ p = l_e - t_s = 3.3\text{in} - 1.5\text{in} = 1.8\text{in} > 1.5'' \text{ thick band, therefore use 1.5 in.} \]

\[ W' = W''p = 18.625\text{lb/in} \times 1.5\text{in} = 28\text{lb} \]

16d Threaded Nail in Shear

\[ t_s = 1.5 \text{ in.}, D_r = 0.139 \text{ in.}, G = 0.36 \]

\[ Z = 79 \text{ lb}^{22} \]

\[ Z' = ZC_D C_M = 79\text{lb} \times 1.25 \times 1.0 = 99\text{lb}^{23} \]

\( \frac{1}{2}'\times3'' \text{ Lag Screw in Withdrawal} \)

\[ D_r = 0.175 \text{ in.}, \text{Effective Length} = 2.75 \text{ in.}, G = 0.36 \]

\[ W = 1800G^{\frac{3}{2}}D_r^{\frac{1}{4}} = 1800 \times 0.36^{\frac{3}{2}} \times 0.175^{\frac{1}{4}} = 105\text{lb/in}^{24} \]

\[ W' = WC_D C_M = 105.2\text{lb/in} \times 1.25 \times 0.7 = 921\text{lb/in}^{25} \]

\[ p = l_e - t_s = 2.75\text{in} - 1.5\text{in} = 1.25\text{in}. \]

\[ W' = W''p = 92\text{lb/in} \times 1.25\text{in} = 115\text{lb} \]

\( \frac{1}{2}'\times3'' \text{ Lag Screw in Shear} \)

From Excel Program:

\[ Z = 109 \text{ lb} \]

\[ Z' = ZC_D C_M = 67\text{lb} \times 1.25 \times 0.7 = 95\text{lb} \]

G.3.6.1.2.2 Actual loads

The actual loads are found using free body diagrams:

---

22 Single shear, NDS-01, Table 11N
23 Adjustment Factors, NDS-01, Table 10.3.1
24 Withdrawal Design Value: NDS-01, Section 11.2.1, eq 11.2-1
25 Adjustment Factors, NDS-01, Table 10.3.1
Figure G.19.  Freebody diagram of 50 lb/ft load on cap rail. The load is horizontal and outwards from the deck. With the infill pickets spaced 8 in on center, each picket carries 34 lb.

Figure G.20.  Free body diagram of infill picket. The 34 lb load is the reaction from the 50 lb/ft on the cap rail. The top connection (a lag screw or nail) must carry 252 lb in withdrawal.
1/2"x3" Lag screw: 252 lb > W' = 115 lb NOT OK
16d Threaded Nail: 252 lb > W' = 33.5 lb NOT OK

Exerted vertically downward, the 50 lb/ft load on the cap rail causes 17 lb in shear at each connection.

1/2"x3" Lag screw: 17 lb < Z' = 95 lb OK
16d Threaded Nail: 17 lb < Z' = 99 lb OK

50 lb/ft² on infill picket

Figure G.21. Free body diagram of the 50 lb/ft² on the infill picket of the railing. It is possible for the entire load to be carried by one picket. The distance, a, varies with the placement on the 50 lb/ft² over the picket.
\[ V_{\text{max}} \text{ when } a = 0, \]
\[ b = L - l - a = 38.5 \text{ in.} - 12 \text{ in.} - 0 = 26.5 \text{ in.} \]
\[ V_{\text{max}} = R_A = \frac{wL}{2L} (2b + l) = \frac{4.2 \text{ lb/in} \cdot 12 \text{ in.} \cdot (2 \cdot 26.5 \text{ in.} + 12 \text{ in.})}{2 \cdot 38.5 \text{ in.}} = 43 \text{ lb} \]

\[ M_{\text{max}} \text{ when } a = \frac{L - l}{2} = \frac{38.5 \text{ in.} - 12 \text{ in.}}{2} = 13.25 \text{ in.} \]
\[ b = L - l - a = 38.5 \text{ in.} - 12 \text{ in.} - 13.25 \text{ in.} = 13.25 \text{ in.} \]
\[ R_A = \frac{wL}{2L} (2b + l) = \frac{4.2 \text{ lb/in} \cdot 12 \text{ in.} \cdot (2 \cdot 13.25 \text{ in.} + 12 \text{ in.})}{2 \cdot 38.5 \text{ in.}} = 25 \text{ lb} \]
\[ M_{\text{max}} = R_A \left( a + \frac{R_A}{2w} \right) = 25 \text{ lb} \left( 13.25 \text{ in.} + \frac{25 \text{ lb}}{2 \cdot 4.2 \text{ lb/in}} \right) = 406 \text{ in.-lb} \]

**Bending:**
\[ f_b \leq F_b' \]
\[ F_b' = F_c C_p C_d C_M = 725 \text{ psi} \cdot 1.5 \cdot 1.25 \cdot 1.0 = 1,359 \text{ psi} \]
\[ S = \frac{bd^2}{6} = \frac{(1.5 \text{ in.})(1.5 \text{ in.})^2}{6} = 0.5625 \text{ in.}^3 \]
\[ f_b = \frac{M}{S} = \frac{406 \text{ in.-lb}}{0.5625 \text{ in.}^3} = 721 \text{ psi} \]
\[ f_b = 721 \text{ psi} \leq F_b' = 1,359 \text{ psi} \quad \text{OK} \]

**Shear:**
\[ f_v \leq F_v' \]
\[ F_v' = F_c C_p C_M = 155 \text{ psi} \cdot 1.25 \cdot 0.97 = 188 \text{ psi} \]
\[ f_v = \frac{3V_{\text{max}}}{2bd} = \frac{3 \cdot 43 \text{ lb}}{2 \cdot 1.5 \text{ in.} \cdot 1.5 \text{ in.}} = 29 \text{ psi} \]
\[ f_v = 29 \text{ psi} \leq F_v' = 188 \text{ psi} \quad \text{OK} \]
G.3.6.1.3 Joist Span

2x8 No. 2 Southern Pine, 16 in. on-center, 40 psf Live plus 10 psf Dead

\[ F_b = 1200 \text{ psi}, \quad F_V = 175 \text{ psi}, \quad S = 13.14 \text{ in.}^3, \quad I = 47.63 \text{ in.}^4 \]

Overhang: \( a = 27 \text{ in.}, \quad \text{Span: } L = 9'-7" = 115 \text{ in.} \)

\[
\begin{align*}
  w &= \frac{(LL + DL)(\text{spacing})}{(12 \text{ in./ft})^2} = \frac{(1000 \text{ lb/ft}^2 + 50 \text{ lb/ft}^2) \times 16 \text{ in.}}{(12 \text{ in./ft})^2} = 5.56 \text{ lb/in} \\
  M_1 &= \frac{w}{8L^2} \left( (L + a)^2 (L - a)^2 \right) = \frac{5.56 \text{ lb/in.}}{8} \left( (115 \text{ in.} + 27 \text{ in.})^2 (115 \text{ in.} - 27 \text{ in.})^2 \right) = 8205 \text{ in.-lb} \\
  M_2 &= \frac{wa^2}{2} = \frac{5.56 \text{ lb/in.} \times (27 \text{ in.})^2}{2} = 2026 \text{ in.-lb} \\
  R_1 = V_1 &= \frac{w}{2L} \left( L^2 - a^2 \right) = \frac{5.56 \text{ lb/in.}}{2} \left( (115 \text{ in.})^2 - (27 \text{ in.})^2 \right) = 302 \text{ lb} \\
  V_2 &= wa = 5.56 \text{ lb/in.} \times 27 \text{ in.} = 150 \text{ lb} \\
  V_3 &= \frac{w}{2L} \left( L^2 + a^2 \right) = \frac{5.56 \text{ lb/in.}}{2} \left( (115 \text{ in.})^2 + (27 \text{ in.})^2 \right) = 337 \text{ lb} \\
  R_2 &= V_2 + V_3 = 150 \text{ lb} + 337 \text{ lb} = 487 \text{ lb} \\
  M_{\text{max}} &= 8205 \text{ in.-lb}, \quad V_{\text{max}} = 337 \text{ lb} \\

g.3.6.1.3.1 \quad \text{Check Joist Bending} \\

f_b \leq F_b, \\

\frac{l_u}{d} = \frac{27 \text{ in.}}{7.25 \text{ in.}} = 3.7 \leq 7 \\

l_e = 1.33l_u = 1.33 \times 27 \text{ in.} = 36.0 \text{ in.} \\

(\text{At Cantilever with uniform load, } l_u/d \leq 7)
\[ R_B = \sqrt{\frac{1 \cdot 7.25}{0.1^2}} = \sqrt{\frac{36in. \cdot 7.25in.}{(1.5in.)^2}} = 10.8 \]

\[ F_{bE} = \frac{K_{bE} \cdot E}{R_B^2} = \frac{0.439 \cdot 1,600,000 \text{ psi}}{10.8^2} = 6,022 \text{ psi} \]

\[ F_b^* = F_b C_F C_D C_r C_M = 1,200 \text{ psi} \times 1.0 \times 1.0 \times 1.15 \times 0.85 = 1,173 \text{ psi} \]

\[ \frac{F_{bE}}{F_b^*} = \frac{6,022 \text{ psi}}{1,173 \text{ psi}} = 5.13 \]

\[ C_L = \left( 1 + \frac{F_{bE}}{F_b^*} \right) - \sqrt{\left( \frac{1 + F_{bE}}{1.9} \right)^2 - \frac{F_{bE}}{0.95}} = \frac{(1 + 5.13)}{1.9} - \sqrt{\left( \frac{1 + 5.13}{1.9} \right)^2 - (5.13)} \]

\[ = 0.99 \approx 1.0 \]

\[ F_b' = F_b C_F C_D C_r C_L C_M = 1,200 \text{ psi} \times 1.0 \times 1.0 \times 1.15 \times 1.0 \times 0.85 = 1,173 \text{ psi} \]

\[ f_b = \frac{M}{S} = \frac{8205 \text{ in.} \cdot \text{lb}}{13.14 \text{ in.}^3} = 624 \text{ psi} \]

\[ f_b = 624 \text{ psi} \leq F_b' = 1,173 \text{ psi} \quad \text{OK} \]

G.3.6.1.3.2 \hspace{1cm} \text{Check Joist Shear}

\[ f_v \leq F_v' \]

\[ F_v' = F_v C_D C_M = 175 \text{ psi} \times 1.0 \times 0.97 = 170 \text{ psi} \]

\[ f_v = \frac{3V_{\text{max}}}{2bd} = \frac{3 \times 337 \text{ lb}}{2 \times 1.5 \text{ in.} \times 7.25 \text{ in.}} = 46 \text{ psi} \]

\[ f_v = 46 \text{ psi} \leq F_v' = 170 \text{ psi} \quad \text{OK} \]

G.3.6.1.3.3 \hspace{1cm} \text{Check Deflection}

\[ \Delta_{\text{max}} \leq \Delta_{\text{allowable}} \]

\[
\Delta_{\text{allowable}} = \frac{L}{360} = \frac{115\text{in.}}{360} = 0.32\text{ in.}
\]
\[
w_{LL} = \frac{40 \text{psf} \times 16\text{in.}}{12 \text{ft}^2} = 53.3\% = 4.4\%.
\]

Midpoint of span, \(x = 57.5\text{ in.}\).
\[
\Delta_{\text{max}} = \frac{w_{LL}x^2}{24EI} \left( L^3 - 2L^2x + LX^2 - 2a^2L^2 + 2a^2x^2 \right)
\]
\[
= \frac{4.4\% \times 57.5\text{in.}}{24 \times 1,600,000 \text{ psi} \times 47.63\text{in.}^4 \times 115\text{in.}^*}
\]
\[
= \frac{4.4\% \times 57.5\text{in.}}{24 \times 1,600,000 \text{ psi} \times 47.63\text{in.}^4 \times 115\text{in.}^*}
\]
\[
= 0.114\text{ in.}
\]

End of overhang, \(x = 27\text{ in.}\).
\[
\Delta_i = \frac{w_{LL}x_i^2}{24EI} \left( 4a^2L - L^3 + 6a^2x_i + 4ax_i^2 + x_i^3 \right)
\]
\[
= \frac{4.4\% \times 27\text{in.}}{24 \times 1,600,000 \text{ psi} \times 47.63\text{in.}^4 \times 27\text{in.}}
\]
\[
= 0.07\text{ in. upward}
\]
\[
\Delta_{\text{max}} = 0.119\text{ in.} \leq \Delta_{\text{allowable}} = 0.32\text{ in.} \quad \text{OK}
\]

G.3.6.1.3.4 Toenail connection of joist to ledger

16d common wire nails, assumed. Southern Pine members, \(G = 0.55\)
\[
Z = 154\text{ lb}^{26}
\]
\[
Z' = Z \times C_D \times C_m \times C_n = 154\text{lb} \times 1.0 \times 0.7 \times 0.83 = 89\text{lb}
\]

Load carried at each connection:

---

26 Lateral Design values of nails in single shear connections: NDS-01, Table 11N
Tributary Area = \frac{16\text{in.}*115\text{in.}}{2} \times \left(\frac{1\text{ft}}{12\text{in.}}\right)^2 = 6.38\text{ft}^2

Design load = (40\text{psf} + 10\text{psf}) \times 6.38\text{ft}^2 = 320\text{lb}

Capacity = 4\text{toenails} \times \frac{89\text{lb}}{\text{toenail}} = 356\text{lb} > 320\text{lb} \quad \text{OK}

G.3.6.1.3.5 Bearing Area for Joist #30

\[ R_2 = 487\text{ lb} \]

\[ f_{c,\text{perp}} \leq F_{c,\text{perp}} ' \]

\( C_p \) applies when the bearing is less than 6 in. in length and more than 3 in. from the end of the member

\[ C_p = \frac{l_b + 0.375}{l_b} = \frac{3\text{in.} + 0.375}{3\text{in.}} = 1.125 \]

\[ F_{c,\text{perp}} ' = F_{c,\text{perp}} C_M C_b = 425\text{ psi} \times 0.67 \times 1.125 = 320\text{ psi} \]

\[ A_b = \frac{1.5\text{in.}}{2} \times 2 \times 1.5 = 2.25\text{in.}^2 \]

\[ f_{c,\text{perp}} = \frac{R_2}{A_b} = \frac{487\text{lb}}{2.25\text{in.}^2} = 216\text{psi} \]

\[ f_{c,\text{perp}} = 216\text{ psi} \leq F_{c,\text{perp}} ' = 320\text{ psi} \quad \text{OK} \]

G.3.6.1.4 Posts

6x6 No. 2 Southern Pine, 55.5 in. high

\( F_c = 525\text{ psi}, E = 1,200,000\text{ psi} \) (wet service)

Tributary Area = 29.8\text{ft}^2, 40\text{psf} \text{ Live}, 10\text{psf} \text{ Dead.}

\[ F_c^* = F_c C_D C_F C_M = 525\text{ psi} \times 1.0 \times 1.0 \times 1.0 = 525\text{ psi} \]
\[
\frac{l_c}{d} = \frac{55.5\text{ in.}}{5.5\text{ in.}} = 10 \leq 50 \quad \text{OK}
\]

\[
F_{cE} = \frac{K_{ce}E}{(l_c/d)^2} = \frac{0.3 \times 1,200,000 \text{ psi}}{(55.5\text{ in}/5.5\text{ in.})^2} = 3,600 \text{ psi}
\]

\[
F_{cE}^* = \frac{3600 \text{ psi}}{525 \text{ psi}} = 6.86
\]

\[
\frac{F_{cE}^*}{C_p} = \frac{1 + \left(\frac{F_{cE}}{F_{cE}^*}\right)}{2c} - \left(\frac{1 + \left(\frac{F_{cE}}{F_{cE}^*}\right)}{2c}\right)^2 = \frac{1 + 6.86}{2 \times 0.8} - \left(\frac{1 + 6.86}{2 \times 0.8}\right)^2 = 0.97
\]

\[
F_c' = F_c C_D C_F C_M C_p = 525 \text{ psi} \times 1.0 \times 1.0 \times 1.0 \times 0.97 = 508 \text{ psi}
\]

\[
P = 29.8 \text{ ft}^2 \times (40 \text{ psf} + 10 \text{ psf}) = 1,500 \text{ lb}
\]

\[
f_c = \frac{P}{bd} = \frac{1500\text{ lb}}{5.5\text{ in} \times 5.5\text{ in}} = 50 \text{ psi}
\]

\[
f_c = 50 \text{ psi} \leq F_c' = 508 \text{ psi} \quad \text{OK}
\]
G.3.6.2 Deck Plans and Drawing

Figure G.22a. Plan view of deck including beam and post numbering.
Figure G.22b. Plan view of deck including joist and rail post numbering.
Figure G.23. Typical section of railing.
Figure G.24. Side view of stairway.
### G.3.6.3 Inspection Tables

Table G.2. Size and condition of railing posts and the deck-post connection.

<table>
<thead>
<tr>
<th>Railing Post Number</th>
<th>Size</th>
<th>Post Condition</th>
<th>Decay Category</th>
<th>Post attachment to deck</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2x4</td>
<td>4</td>
<td>5&quot; split, continues to top</td>
<td>Type B</td>
</tr>
<tr>
<td>2</td>
<td>2x4</td>
<td>4</td>
<td>Type A</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>2x4</td>
<td>Insect holes</td>
<td>4</td>
<td>Type B</td>
</tr>
<tr>
<td>4</td>
<td>2x4</td>
<td>4</td>
<td>8&quot;split</td>
<td>Type A</td>
</tr>
<tr>
<td>5</td>
<td>2x4</td>
<td>4</td>
<td>Vertical 3/4&quot; kerf at notch, 3/4&quot; check, continues to top</td>
<td>Type A</td>
</tr>
<tr>
<td>6</td>
<td>2x4</td>
<td>4</td>
<td>Type A</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>2x4</td>
<td>4</td>
<td>2&quot; split, continues to top</td>
<td>Type B</td>
</tr>
<tr>
<td>8</td>
<td>2x4</td>
<td>4</td>
<td>3 screws</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>2x4</td>
<td>Contact with ground</td>
<td>2 Horizontal 1/4&quot; kerf, check to top</td>
<td>Type A with screw at split</td>
</tr>
<tr>
<td>10</td>
<td>2x4</td>
<td>4</td>
<td>6.25&quot; split at notch, continues to top</td>
<td>Type A</td>
</tr>
<tr>
<td>11</td>
<td>2x4</td>
<td>4</td>
<td>2&quot; split at notch</td>
<td>Type B</td>
</tr>
<tr>
<td>12</td>
<td>2x4</td>
<td>4</td>
<td>Vertical 1.5&quot; kerf on one side</td>
<td>Type A</td>
</tr>
<tr>
<td>13</td>
<td>2x4</td>
<td>4</td>
<td>28&quot; check at notch</td>
<td>Type B</td>
</tr>
<tr>
<td>14</td>
<td>2x4</td>
<td>4</td>
<td>Split closed with screw</td>
<td>Type A with screw at split</td>
</tr>
<tr>
<td>15</td>
<td>2x4</td>
<td>4</td>
<td>Type A, no washer</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>2x4</td>
<td>4</td>
<td>Type B, no washer</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>2x4</td>
<td>One Side Hidden</td>
<td>4</td>
<td>Type A, no washer</td>
</tr>
</tbody>
</table>

*Connection type A is two 1/4"x3" lag screws and one 16d annular threaded nail. Connection type B is one two nails and one lag screw.
### Table G.3. Condition of railing infill

<table>
<thead>
<tr>
<th>Infill Between Post Numbers</th>
<th>Condition of infill</th>
<th>Infill Attachment to posts</th>
<th>Cap Rail</th>
<th>Top/Bottom Rail</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>Some mildew</td>
<td>N/A</td>
<td></td>
<td>Knots</td>
</tr>
<tr>
<td>2-3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4-5</td>
<td>Knot holes, mildew</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5-6</td>
<td>Insect holes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6-7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7-8</td>
<td>Insect holes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9-10</td>
<td>Some loose</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10-11</td>
<td></td>
<td>Not inspected from outside because of height</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11-12</td>
<td></td>
<td>Not inspected from outside because of height</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12-13</td>
<td></td>
<td>Not inspected from outside</td>
<td></td>
<td>Bee hole</td>
</tr>
<tr>
<td>13-14</td>
<td></td>
<td>Not inspected from outside because of height</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14-15</td>
<td>Very Flexible</td>
<td>Not inspected from outside because of height</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15-16</td>
<td></td>
<td>Not inspected from outside because of height</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Table G.4. Size, span and condition of joists and joist fasteners.

<table>
<thead>
<tr>
<th>Joist Number</th>
<th>Size</th>
<th>Span</th>
<th>Overhang</th>
<th>Attachment to Beam/Girder</th>
<th>Attachment to Ledger</th>
<th>Decay Category</th>
<th>Joist Condition</th>
<th>Meets NDS-01 Design Criteria*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2x8</td>
<td>9'-7&quot;</td>
<td>27&quot;</td>
<td>OK</td>
<td>OK</td>
<td>4</td>
<td>4</td>
<td>OK</td>
</tr>
<tr>
<td>2</td>
<td>2x8</td>
<td>9'-7&quot;</td>
<td>27&quot;</td>
<td>OK</td>
<td>OK</td>
<td>4</td>
<td>4</td>
<td>OK</td>
</tr>
<tr>
<td>3</td>
<td>2x8</td>
<td>9'-7&quot;</td>
<td>27&quot;</td>
<td>OK</td>
<td>OK</td>
<td>4</td>
<td>4</td>
<td>OK</td>
</tr>
<tr>
<td>4</td>
<td>2x8</td>
<td>9'-7&quot;</td>
<td>27&quot;</td>
<td>OK</td>
<td>OK</td>
<td>4</td>
<td>4</td>
<td>OK</td>
</tr>
<tr>
<td>5</td>
<td>2x8</td>
<td>9'-7&quot;</td>
<td>27&quot;</td>
<td>OK</td>
<td>OK</td>
<td>4</td>
<td>4</td>
<td>OK</td>
</tr>
<tr>
<td>6</td>
<td>2x8</td>
<td>9'-7&quot;</td>
<td>27&quot;</td>
<td>OK</td>
<td>OK</td>
<td>4</td>
<td>4</td>
<td>OK</td>
</tr>
<tr>
<td>7</td>
<td>2x8</td>
<td>9'-7&quot;</td>
<td>27&quot;</td>
<td>OK</td>
<td>OK</td>
<td>4</td>
<td>4</td>
<td>OK</td>
</tr>
<tr>
<td>8</td>
<td>2x8</td>
<td>9'-7&quot;</td>
<td>27&quot;</td>
<td>OK</td>
<td>OK</td>
<td>4</td>
<td>4</td>
<td>OK</td>
</tr>
<tr>
<td>9</td>
<td>2x8</td>
<td>9'-7&quot;</td>
<td>27&quot;</td>
<td>OK</td>
<td>OK</td>
<td>4</td>
<td>4</td>
<td>OK</td>
</tr>
<tr>
<td>10</td>
<td>2x8</td>
<td>9'-7&quot;</td>
<td>27&quot;</td>
<td>OK</td>
<td>OK</td>
<td>4</td>
<td>4</td>
<td>OK</td>
</tr>
<tr>
<td>11</td>
<td>2x8</td>
<td>9'-7&quot;</td>
<td>27&quot;</td>
<td>OK</td>
<td>OK</td>
<td>4</td>
<td>4</td>
<td>OK</td>
</tr>
<tr>
<td>12</td>
<td>2x8</td>
<td>9'-7&quot;</td>
<td>27&quot;</td>
<td>OK</td>
<td>OK</td>
<td>4</td>
<td>4</td>
<td>OK</td>
</tr>
<tr>
<td>13</td>
<td>2x8</td>
<td>9'-7&quot;</td>
<td>27&quot;</td>
<td>OK</td>
<td>OK</td>
<td>4</td>
<td>4</td>
<td>OK</td>
</tr>
<tr>
<td>14</td>
<td>2x8</td>
<td>9'-7&quot;</td>
<td>27&quot;</td>
<td>OK</td>
<td>OK</td>
<td>4</td>
<td>4</td>
<td>OK</td>
</tr>
<tr>
<td>15</td>
<td>2x12</td>
<td>6'</td>
<td>23&quot;</td>
<td>OK</td>
<td>OK</td>
<td>4</td>
<td>4</td>
<td>OK</td>
</tr>
</tbody>
</table>

*Criteria checked according to the methods described in NDS-01 are: bending stress, shear stress and deflection
Table G.4. Size, span and condition of joists and joist fasteners (continued)

<table>
<thead>
<tr>
<th>Joist Number</th>
<th>Overhang</th>
<th>Span</th>
<th>Size</th>
<th>Meets NDS-01 Design Criteria*</th>
<th>Attachment to Beam/Girder</th>
<th>Attachment to Ledger</th>
<th>Decay Category</th>
<th>Joist Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>2x8</td>
<td>9'7&quot;</td>
<td>23&quot;</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>4</td>
<td>Mildew</td>
</tr>
<tr>
<td>17</td>
<td>2x8</td>
<td>9'7&quot;</td>
<td>23&quot;</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>4</td>
<td>Check near ledger, not decay</td>
</tr>
<tr>
<td>18</td>
<td>2x8</td>
<td>9'7&quot;</td>
<td>23&quot;</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>4</td>
<td>Check near ledger, not decay</td>
</tr>
<tr>
<td>19</td>
<td>2x8</td>
<td>9'7&quot;</td>
<td>23&quot;</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>4</td>
<td>Check near ledger, not decay</td>
</tr>
<tr>
<td>20</td>
<td>2x8</td>
<td>9'7&quot;</td>
<td>23&quot;</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>4</td>
<td>Check near ledger, not decay</td>
</tr>
<tr>
<td>21</td>
<td>2x8</td>
<td>9'7&quot;</td>
<td>23&quot;</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>4</td>
<td>Check near ledger, not decay</td>
</tr>
<tr>
<td>22</td>
<td>2x8</td>
<td>9'7&quot;</td>
<td>23&quot;</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>4</td>
<td>Check near ledger, not decay</td>
</tr>
<tr>
<td>23</td>
<td>2x8</td>
<td>9'7&quot;</td>
<td>23&quot;</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>4</td>
<td>Check near ledger, not decay</td>
</tr>
<tr>
<td>24</td>
<td>2x8</td>
<td>9'7&quot;</td>
<td>23&quot;</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>4</td>
<td>Check near ledger, not decay</td>
</tr>
<tr>
<td>25</td>
<td>2x8</td>
<td>9'7&quot;</td>
<td>23&quot;</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>4</td>
<td>Check near ledger, not decay</td>
</tr>
<tr>
<td>26</td>
<td>2x8</td>
<td>9'7&quot;</td>
<td>23&quot;</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>4</td>
<td>Check near ledger, not decay</td>
</tr>
<tr>
<td>27</td>
<td>2x8</td>
<td>9'7&quot;</td>
<td>23&quot;</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>4</td>
<td>Check near ledger, not decay</td>
</tr>
<tr>
<td>28</td>
<td>2x8</td>
<td>9'7&quot;</td>
<td>23&quot;</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>4</td>
<td>Check near ledger, not decay</td>
</tr>
<tr>
<td>29</td>
<td>2x8</td>
<td>9'7&quot;</td>
<td>23&quot;</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>4</td>
<td>Check near ledger, not decay</td>
</tr>
<tr>
<td>30</td>
<td>2x8</td>
<td>9'7&quot;</td>
<td>23&quot;</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>4</td>
<td>Check near ledger, not decay</td>
</tr>
</tbody>
</table>

*Criteria checked according to the methods described in NDS-01 are: bending stress, shear stress and deflection.
Table G.4.  Size, span and condition of joists and joist fasteners (continued)

<table>
<thead>
<tr>
<th>Joist Number</th>
<th>Size</th>
<th>Span</th>
<th>Overhang</th>
<th>Attachment to Beam/Girder</th>
<th>Attachment to Ledger</th>
<th>Decay Category</th>
<th>Joist Condition</th>
<th>Meets NDS-01 Design Criteria*</th>
</tr>
</thead>
<tbody>
<tr>
<td>31</td>
<td>2x8</td>
<td>9'-1&quot;</td>
<td>0</td>
<td>Toenailed to beam #6</td>
<td></td>
<td></td>
<td>White Mold</td>
<td>OK</td>
</tr>
<tr>
<td>32</td>
<td>2x8</td>
<td>6'-5 1/4&quot;</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td>Hidden</td>
<td>OK</td>
</tr>
<tr>
<td>33</td>
<td>2x8</td>
<td>3'-10&quot;</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td>Hidden</td>
<td>OK</td>
</tr>
<tr>
<td>34</td>
<td>2x8</td>
<td>1'-2 1/2&quot;</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td>Hidden</td>
<td>OK</td>
</tr>
<tr>
<td>35</td>
<td>2x8</td>
<td>6'-10 1/4&quot;</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td>Hidden</td>
<td>OK</td>
</tr>
<tr>
<td>36</td>
<td>2x8</td>
<td>5'-6 1/2&quot;</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td>Hidden</td>
<td>OK</td>
</tr>
<tr>
<td>37</td>
<td>2x8</td>
<td>4'-3&quot;</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td>Hidden</td>
<td>OK</td>
</tr>
<tr>
<td>38</td>
<td>2x8</td>
<td>2'-11 1/4&quot;</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td>Hidden</td>
<td>OK</td>
</tr>
<tr>
<td>39</td>
<td>2x8</td>
<td>1'-7 1/2&quot;</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Criteria checked according to the methods described in NDS-01 are: bending stress, shear stress and deflection
Table G.5. Size, span, and condition of beams and beam fasteners.

<table>
<thead>
<tr>
<th>Beam Span Number</th>
<th>Size</th>
<th>Span</th>
<th>Overhang</th>
<th>Species</th>
<th>Attachment to Post</th>
<th>Decay Category</th>
<th>Beam Condition</th>
<th>Meets NDS-01 Design Criteria*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2x12</td>
<td>8'-9 1/2&quot;</td>
<td>0</td>
<td>No.2 S.P.</td>
<td>2</td>
<td>4</td>
<td>OK</td>
<td>OK</td>
</tr>
<tr>
<td>2</td>
<td>2x12</td>
<td>8'-7 3/4&quot;</td>
<td>0</td>
<td>No.2 S.P.</td>
<td>2</td>
<td>4</td>
<td>OK</td>
<td>OK</td>
</tr>
<tr>
<td>3</td>
<td>2x12</td>
<td>9'-6&quot;</td>
<td>0</td>
<td>No.2 S.P.</td>
<td>5</td>
<td>4</td>
<td>OK</td>
<td>OK</td>
</tr>
<tr>
<td>4</td>
<td>2x12</td>
<td>10'-1/2&quot;</td>
<td>0</td>
<td>No.2 S.P.</td>
<td>6</td>
<td>4</td>
<td>OK</td>
<td>OK</td>
</tr>
<tr>
<td>5</td>
<td>2x12</td>
<td>8'-2&quot;</td>
<td></td>
<td>No.1 Cedar</td>
<td>6</td>
<td>4</td>
<td>OK</td>
<td>OK</td>
</tr>
<tr>
<td>6</td>
<td>2x8</td>
<td>8'-2&quot;</td>
<td></td>
<td>No.2 S.P.</td>
<td>7</td>
<td>4</td>
<td>OK</td>
<td>OK</td>
</tr>
<tr>
<td>7</td>
<td>2x12</td>
<td>38&quot;</td>
<td></td>
<td>No.1 Cedar</td>
<td>8</td>
<td>4</td>
<td>OK</td>
<td>OK</td>
</tr>
<tr>
<td>8</td>
<td>2x12</td>
<td>6'-11&quot;</td>
<td></td>
<td>No.1 Cedar</td>
<td>9</td>
<td>4</td>
<td>OK</td>
<td>OK</td>
</tr>
<tr>
<td>9</td>
<td>2x12</td>
<td>9'-7&quot;</td>
<td>25&quot;</td>
<td>No.2 S.P.</td>
<td>10</td>
<td>4</td>
<td>OK</td>
<td>OK</td>
</tr>
<tr>
<td>10</td>
<td>2x8</td>
<td>11'-6&quot;</td>
<td>0</td>
<td>No.2 S.P.</td>
<td></td>
<td>4</td>
<td>OK</td>
<td>OK</td>
</tr>
</tbody>
</table>

*Criteria checked according to the methods described in NDS-01 are: bending stress, shear stress and deflection
Table G.6.  Size and condition of deck posts.

<table>
<thead>
<tr>
<th>Post Number</th>
<th>Size</th>
<th>Height</th>
<th>Decay Category</th>
<th>Post Condition</th>
<th>Meets NDS-01 Design Criteria*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6x6</td>
<td>55 1/2&quot;</td>
<td>3</td>
<td>1/4&quot; Horizontal Kerf, Checks at notch - 6&quot; and 2 1/2&quot;</td>
<td>OK</td>
</tr>
<tr>
<td>2</td>
<td>6x6</td>
<td>56&quot;</td>
<td>3</td>
<td>1&quot; Horizontal kerf</td>
<td>OK</td>
</tr>
<tr>
<td>3</td>
<td>6x6</td>
<td>52 1/2&quot;</td>
<td>3</td>
<td>One Side Hidden, attached to house frame with lag screw</td>
<td>OK</td>
</tr>
<tr>
<td>4</td>
<td>4x4</td>
<td>55&quot;</td>
<td>3</td>
<td>Notch 1.5&quot;x1.5&quot;x11.25&quot; for Beam 8</td>
<td>OK</td>
</tr>
<tr>
<td>5</td>
<td>6x6</td>
<td>55&quot;</td>
<td>3</td>
<td></td>
<td>OK</td>
</tr>
<tr>
<td>6</td>
<td>6x6</td>
<td>63&quot;</td>
<td>3</td>
<td></td>
<td>OK</td>
</tr>
<tr>
<td>7</td>
<td>6x6</td>
<td>78&quot;</td>
<td>3</td>
<td>Horizontal kerf</td>
<td>OK</td>
</tr>
<tr>
<td>8</td>
<td>6x6</td>
<td>87 1/2&quot;</td>
<td>3</td>
<td></td>
<td>OK</td>
</tr>
</tbody>
</table>

*Criteria checked according to the methods described in NDS-01 is compression stress parallel-to-grain

Table G.7.  The condition of stairway risers, listed from bottom to top.

<table>
<thead>
<tr>
<th>Riser Number</th>
<th>Condition of Riser</th>
<th>Decay Category</th>
<th>Attachment to Stringer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3 Water trapping for all risers (1-7)</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>3 White mold on bottom of all risers (1-7)</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>1 3/4&quot; Knot Hole</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>4 Bottom is hidden</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>4 Bottom is hidden</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>4</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>4</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

Table G.8.  The condition of stairway stringers.

<table>
<thead>
<tr>
<th>Stringer Number</th>
<th>Condition</th>
<th>Decay Category</th>
<th>Attachment to beam</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>3</td>
<td>3 nails that go through beams 9 and 7</td>
</tr>
<tr>
<td>2 (center)</td>
<td>Few small splits</td>
<td>3</td>
<td>2 nails, 1/4&quot; spacer</td>
</tr>
<tr>
<td>3 (outside)</td>
<td>Few small splits</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Under Stairs 8 &amp; 9</td>
<td></td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>
G.4 References


Council of American Building Officials (CABO). 1995. CABO one and two family dwelling code. Falls Church, VA: CABO


Robertson, R. 2002. Personal communication. Building Official, Chesterfield County, VA.

9.3 Appendix C: Supplemental Worksheets for the Inspection of Residential Wood Decks and Balconies

9.3.1 Supplemental Worksheets for the Inspection of Residential Wood Decks
A. Pre Inspection

Age of Deck:

Was the deck part of the original construction of the house?

Do building plans exist for the deck?

Has the deck ever been inspected? Are there reports from previous inspections?

Are there any specific problem areas?

Has there been any damage, repair, replacements or modifications since the deck was built?

B. Plan View and Elevations

Scale: 1 Block =

Figure B.1. Plan view of deck including beam, joist, and railing numbering.
B. Plan View and Elevations (continued)

Figure B.1. Typical railing and stairway sections.

Table C.1. Size and condition of railing posts and the deck-post connection.

<table>
<thead>
<tr>
<th>Railing Post Number</th>
<th>Size</th>
<th>Post Condition - Decay Category</th>
<th>Post Attachment to Deck - Notched, Condition of Post at Connection</th>
<th>Post Attachment to Deck - Fastener Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
</tbody>
</table>

C. Railings

Railing posts:
Height:
Material:
Attachment to deck:

Connection to deck:
Length:
Shank Diameter:
Root Diameter:

Infill:
Height from Deck surface:
Material:
Openings:
### C. Railings (continued)

#### Table C.1. Condition of railing infill

<table>
<thead>
<tr>
<th>Infill Between Post Numbers</th>
<th>Condition of Infill</th>
<th>Infill Attachment to Posts - Condition</th>
<th>Cap Rail</th>
<th>Top and Bottom Rail</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

### D. Decking

- **Material:**
- **Level:**
- **Size:**
- **Attachment to Joists:**
- **Treatment:**
- **Nail pop-up conditions:**
- **Paints / Stains / Water Sealants:**

### E. Joists

- **Material:**
- **Spacing:**
- **Attachment to ledger:**
  - **Fastener Type:**
- **Attachment to Beam/Girder:**
  - **Fastener Type:**

#### Table E.1. Size, span and condition of joists and joist fasteners.

<table>
<thead>
<tr>
<th>Joist Number</th>
<th>Size</th>
<th>Span</th>
<th>Overhang</th>
<th>Joist Condition - Decay Category, Ground Exposure</th>
<th>Attachment to Ledger - Condition</th>
<th>Attachment to Beam/Girder - Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
### F. Beams/Girders

- **Attachment to Building:**
- **Fastener tightness:**
- **Material:**
- **Treatment:**

**Built-Up Beams:**
- **Nail Spacing / Patterns:**
- **Edge Distances:**
- **Additional Material:**

#### Table F.1. Size, span and condition of beams and beam fasteners.

<table>
<thead>
<tr>
<th>Beam Span Number</th>
<th>Size</th>
<th>Span</th>
<th>Beam Condition - Decay Category, Ground Exposure</th>
<th>Attachment to Building</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
</tbody>
</table>

### G. Posts

- **Slope of ground beneath deck:**
- **Condition of ground beneath deck:**

- **Material:**
- **Treatment:**

- **Footing type:**
- **Attachment to footing:**
- **Depth of footing:**

#### Table G.1. Size and condition of posts and footings

<table>
<thead>
<tr>
<th>Post Number</th>
<th>Size</th>
<th>Height</th>
<th>Post Condition - Decay Category, Ground/Masonry Exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

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9. Appendix C: Deck and Balcony Worksheets
### H. Stairways

| Stringer type: | Total width: |
| Graspable Handrails: | Total rise: |
| Guardrail height: | Total run: |
| Material: | Riser span: |
| Connection of stringer to deck: | Tread width: |
| Stringer spans: | Riser height: |
| Size of Openings: | Riser connection to stringer: |

#### Table H.1. Condition of Stairway Stringers

<table>
<thead>
<tr>
<th>Stringer Number</th>
<th>Condition of Stringer</th>
<th>Attachment to Deck</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>

### H. Stairways (continued)

#### Table H.2. Condition of stairway risers

<table>
<thead>
<tr>
<th>Riser Number</th>
<th>Condition of Riser - Decay Category</th>
<th>Attachment of Riser to Stringer - Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
I. Attachment at Ledger

Figure G.1. Dimensions of ledger board, fastener locations (include edge distances and spacings), joist attachment (locations and spacings) and problem areas.

Figure G.2. Cross-section view of ledger board attachment including presence and coverage of flashing, penetration of lag screws or bolts and materials between ledger and band joist.

G. Attachment at Ledger (continued)

<table>
<thead>
<tr>
<th>Flashing:</th>
<th>Band Joist:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material:</td>
<td>Material:</td>
</tr>
<tr>
<td>Coverage:</td>
<td>Treatment:</td>
</tr>
<tr>
<td>Condition:</td>
<td>Inside View:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ledger:</th>
<th>Ledger Connection to house:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size:</td>
<td>Fastener Type:</td>
</tr>
<tr>
<td>Material:</td>
<td>Length:</td>
</tr>
<tr>
<td>Treatment:</td>
<td>Shank Diameter:</td>
</tr>
<tr>
<td>Exposure:</td>
<td>Root Diameter:</td>
</tr>
<tr>
<td>Decay category:</td>
<td>Spacing:</td>
</tr>
</tbody>
</table>

H. Lateral Support / Bracing

How is the balcony laterally supported? Connection to deck / post:

| Material: | Treatment: | Condition: |

I. Other

Condition of decorative trim:
Are there hidden members that could not be checked?
Other Concerns:
9.3.2 Supplemental Worksheets for the Inspection of Residential Wood Balconies
A. Pre Inspection

Age of Balcony:

Was the balcony part of the original construction of the house?

Do building plans exist for the balcony?

Has the balcony ever been inspected? Are there reports from previous inspections?

Are there any specific problem areas?

Has there been any damage, repair, replacements or modifications since the balcony was built?

B. Plan View and Elevations

Scale: 1 Block =

Figure B.1. Plan view of balcony including beam, joist, and railing numbering.

9. Appendix C: Deck and Balcony Worksheets
B. Plan View and Elevations (continued)

![Diagram]

Figure B.1. Typical rail section.

C. Railings

<table>
<thead>
<tr>
<th>Railing posts:</th>
<th>Infill:</th>
<th>Height:</th>
<th>Height from Deck surface:</th>
<th>Material:</th>
<th>Material:</th>
<th>Openings:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Railing posts:</td>
<td>Height:</td>
<td>Attachment to deck:</td>
<td>Length:</td>
<td>Shank Diameter:</td>
<td>Root Diameter:</td>
</tr>
</tbody>
</table>

Table C.1. Size and condition of railing posts and the deck-post connection.

<table>
<thead>
<tr>
<th>Railing Post Number</th>
<th>Size</th>
<th>Post Condition - Decay Category</th>
<th>Post Attachment to Deck - Notched, Condition of Post at Connection</th>
<th>Post Attachment to Deck - Fastener Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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</tbody>
</table>

9. Appendix C: Deck and Balcony Worksheets
C. Railings (continued)

Table C.1. Condition of railing infill

<table>
<thead>
<tr>
<th>Infill Between Post Numbers</th>
<th>Condition of Infill</th>
<th>Infill Attachment to Posts - Condition</th>
<th>Cap Rail</th>
<th>Top and Bottom Rail</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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D. Decking

- Material:
- Size:
- Treatment:
- Paints / Stains / Water Sealants:

E. Joists

- Material:
- Treatment:
- Spacing:
- Attachment to ledger:
  - Fastener Type:
- Attachment to Beam/Girder:
  - Fastener Type:

Table E.1. Size, span and condition of joists and joist fasteners.

<table>
<thead>
<tr>
<th>Joist Number</th>
<th>Size</th>
<th>Span</th>
<th>Overhang</th>
<th>Joist Condition - Decay Category, Ground Exposure</th>
<th>Attachment to Ledger - Condition</th>
<th>Attachment to Beam/Girder - Condition</th>
</tr>
</thead>
<tbody>
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</table>

9. Appendix C: Deck and Balcony Worksheets
Table F.1. Size, span and condition of beams and beam fasteners.

<table>
<thead>
<tr>
<th>Beam Span Number</th>
<th>Size</th>
<th>Span</th>
<th>Beam Condition - Decay Category, Ground Exposure</th>
<th>Attachment to Building</th>
</tr>
</thead>
<tbody>
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</tbody>
</table>

Figure G.1. Dimensions of ledger board, fastener locations (include edge distances and spacings), joist attachment (locations and spacings) and problem areas.

Figure G.2. Cross-section view of ledger board attachment including presence and coverage of flashing, penetration of lag screws or bolts and materials between ledger and band joist.
### G. Attachment at Ledger (continued)

<table>
<thead>
<tr>
<th>Flashing</th>
<th>Band Joist</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>Material</td>
</tr>
<tr>
<td>Coverage</td>
<td>Treatment</td>
</tr>
<tr>
<td>Condition</td>
<td>Inside View</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ledger</th>
<th>Ledger Connection to house</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>Fastener Type</td>
</tr>
<tr>
<td>Material</td>
<td>Length</td>
</tr>
<tr>
<td>Treatment</td>
<td>Shank Diameter</td>
</tr>
<tr>
<td>Exposure</td>
<td>Root Diameter</td>
</tr>
<tr>
<td>Decay category</td>
<td>Spacing</td>
</tr>
</tbody>
</table>

### H. Lateral Support / Bracing

How is the balcony laterally supported?
- Material:
- Treatment:
- Condition:
- Connection to deck / post:

### I. Other

- Condition of decorative trim:
- Are there hidden members that could not be checked?
- Other Concerns: