CALDERWOOD ENGINEERING
222 RIVER ROAD
RICHMOND, ME 04357
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Project: 593 Washington Avenue, Portland Me.
Client: Michael Pare

Engineering Design Computations: Calderwood Engineering
Design Computations by: Eric T. Calderwood, PE
Field Measurements by: Jesse J. Helms

Project Notes:
Note the building is fully constructed and the attic apartment is currently vacant and awaiting an engineering analysis of the existing building framing in order to verify that it is safe to use as a finished building space.

Live Load: 40 psf live load per IBC requirements 30 psf allowed for sleeping areas - 40 psf used everywhere

$p_{flring} := 3\ psf$ — *3 psf allowed for carpet and pad, hardwood, or vinyl - we do not recommend installing ceramic or stone tile on the 3rd floor.*

$\gamma_{wood} := 40\ pcf$

$E_{spf1} := 1200000\ psi$

$p_{wdl} := 3.5\ psf$ — *subflooring dead load*

$L_{sp} := 13\ ft$ — *maximum span for floor joists*

$\gamma_{foam} := 2\ pcf$ — *density of foam insulation for closed cell foam*

$p_{wLL} := 40\ psf$

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Floor Joists Design Check: $d := 5.75\ in$ $b := 2.0\ in$

$S_{xj} := \frac{d^2 \cdot b}{6} = 11.0208\ in^3$

$I_{xj} := \frac{d^3 \cdot b}{12} = 31.6849\ in^4$

$A_j := d \cdot b = 11.5\ in^2$

$J_{sp} := 13\ ft$

$S_{joists} := 16\ in$

$\frac{d}{b} = 2.875$

$S_{blocking} := 7\ ft$ *assumed based on framing in basement*

$\omega_{dl} := p_{wdl} \cdot S_{joists} + d \cdot b \cdot \gamma_{wood} = 7.8611\ plf$

$\omega_{ll} := p_{wLL} \cdot S_{joists} = 53.3333\ plf$

$M_{joist} := \frac{(\omega_{ll} + \omega_{dl}) \cdot J_{sp}^2}{8} = 1292.7326\ ft \cdot lbf$

$f_b := \frac{M_{joist}}{S_{xj}} = 1407.5879\ psi$

$\Delta_{llj} := \frac{5 \cdot \omega_{ll} \cdot J_{sp}^4}{384 \cdot E_{spf1} \cdot I_{xj}} = 0.9014\ in$

$\frac{J_{sp}}{\Delta_{llj}} = 173.0627$ *deflection is > than L/360 therefor does not meet code requirements*

$F_b := 875\ psi$

$C_r := 1.15$ *more than 3 members spaced <=24" and fastened together sufficiently to transfer load with flooring & blocking (4.3.9 NDS)*

$C_d := 1.00$ *Use Cd=1.00 for consideration of normal live loads 2.3.2 NDS*

$C_t := 1.0$ *Use will be Less than 150 degrees F sustained 2.3.3 NDS*

$C_L := 1.0$ *Ends and compression face are prevented from rotation via plank fastening/ end support blocking NDS 3.3.3.3 mid span blocking is also provided*

$C_f := 1.3$ *for 2x6s Table 4A*

$C_i := 1.0$ *no incising*

$C_m := 1.0$ *used in dry conditions*

$C_{fu} := 1.0$ *not being used flat*

$F'_b := F_b \cdot C_r \cdot C_d \cdot C_t \cdot C_L \cdot C_f \cdot C_i \cdot C_m \cdot C_{fu} = 1308.125\ psi$ *1408 psi >> 1308 psi therefor strengthening req'd*

Floor Joist retrofit req'd for flexure:

The 2nd floor apartment is occupied and the depth of the joists was visible in a small area of the 3rd floor - before committing to a strengthening plan this report recommends verifying that the actual size of the joists for the 3rd floor are 2"x5.75" at 16" centers. If in fact these measurments are in error it may reduce or increase the amount of strengthening required.

$$M_{ok} := S_{xj} \cdot F'_b = 1201.39 \ \text{ft} \cdot \text{lbf}$$

$$V_{jst} := \frac{(\omega_{dl} + \omega_{ll}) \cdot J_{sp}}{2} = 397.7639 \ \text{lbf}$$

$$L_{ok} := 4.7722 \ \text{ft}$$

$$M_{Lok} := \frac{2 \cdot V_{jst} - (\omega_{dl} + \omega_{ll}) \cdot L_{ok}}{2} \cdot L_{ok} = 1201.39 \ \text{ft} \cdot \text{lbf}$$

only strengthening the center 8 feet of joist will be sufficient to increase the flexural capacity of the system and bring the stresses down to acceptable stress levels.

$$f_{vhz} := \frac{V_{jst} \cdot 3}{2 \cdot d \cdot b} = 51.8822 \ \text{psi}$$

by definition horizontal shear stress at NA of rectangular section (ref NDS 3.4.2 eqn 3.4-2) - note shear is calculated at the reaction for this joist which is conservative - shear design section is allowed to be taken at a distance d from the support, but that will result in a lower stress and therefor we are not concerned with it.

$$F_v := 135 \ \text{psi}$$

$C_d := 1.00$ *Use Cd=1.00 for normal duration of live loads 2.3.2 NDS*

$C_t := 1.0$ *Use will be Less than 150 degrees F sustained 2.3.3 NDS*

$C_m := 1.00$ *joists are used in the dry - elevated moisture content is not a concern*

$$F'_v := F_v \cdot C_d \cdot C_t \cdot C_m = 135 \ \text{psi}$$

Allowable Horizontal Shear stress is greater than applied horizontal shear stress therefor okay - again only the center 8' need be strengthened - also note that if we use a liquid nails or similar construction adhesive the shear carrying capacity of the adhesive is > 135 psi and therefor we do not need to be concerned with horizontal shear carrying capacity of the adhesive or retrofit.

Add a single 2x4 8ft long to each joist centered on the midspan - weak axis - acting composite for live load only

$$Y_{bar} := \frac{1.5\ in \cdot 3.5\ in \cdot 0.75\ in + d \cdot b \cdot \left(\frac{d}{2} + 1.5\ in\right)}{1.5\ in \cdot 3.5\ in + d \cdot b} = 3.2388\ in$$

$$I_{xcomp} := (1.5\ in)^3 \cdot 3.5\ in + 1.5\ in \cdot 3.5\ in \cdot \left(Y_{bar} - 0.75\ in\right)^2 + I_{xj} + d \cdot b \cdot \left(\frac{d}{2} + 1.5\ in - Y_{bar}\right)^2 = 90.8625\ in^4$$

$$S_{bcomp} := \frac{I_{xcomp}}{Y_{bar}} = 28.0543\ in^3 \qquad S_{tcomp} := \frac{I_{xcomp}}{\left(d + 1.5\ in - Y_{bar}\right)} = 22.6522\ in^3$$

$$\omega_{dl} := p_{wdl} \cdot S_{joists} + (d \cdot b + 1.5\ in \cdot 3.5\ in) \cdot \gamma_{wood} = 9.3194\ plf$$

$$M_{jdl} := \frac{\omega_{dl} \cdot {J_{sp}}^2}{8} = 196.8733\ ft \cdot lbf \qquad M_{jLL} := \frac{\omega_{ll} \cdot {J_{sp}}^2}{8} = 1126.6667\ ft \cdot lbf$$

$$f_b := \frac{M_{jdl}}{S_{xj}} + \frac{M_{jLL}}{min\left(S_{bcomp}, S_{tcomp}\right)} = 811.2156\ psi$$

by inspection this lower bending stress is acceptable for the grade of lumber used - this is for the retrofit section

Calculate beam live load deflection using the moment area method:

Deflection due to Live Load by Moment Area Method for varying section properties									
ω=	4.4444444	lbs/in							
X	Shear	Vdx	Icomp	EI	Mdx/EI	SumMXdx/EI	? - Slope	Delta Y - in	Y
in	lbs		in^4		radians		Radians	(Approx)	inches
0.00	346.67	0.00	31.68	3.80E+07	0.00E+00	0.0000	-8.45E-03	0.0000	0.000
6.50	317.78	2159.44	31.68	3.80E+07	1.85E-04	0.0006	-8.27E-03	-0.0543	-0.054
13.00	288.89	1971.67	31.68	3.80E+07	5.38E-04	0.0058	-7.73E-03	-0.0520	-0.106
19.50	260.00	1783.89	31.68	3.80E+07	8.59E-04	0.0198	-6.87E-03	-0.0474	-0.154
26.00	231.11	1596.11	31.68	3.80E+07	1.15E-03	0.0459	-5.72E-03	-0.0409	-0.195
32.50	202.22	1408.33	90.86	1.09E+08	7.26E-04	0.0450	-5.00E-03	-0.0348	-0.230
39.00	173.33	1220.56	90.86	1.09E+08	5.68E-04	0.0506	-4.43E-03	-0.0306	-0.260
45.50	144.44	1032.78	90.86	1.09E+08	6.35E-04	0.0775	-3.79E-03	-0.0267	-0.287
52.00	115.56	845.00	90.86	1.09E+08	6.91E-04	0.1112	-3.10E-03	-0.0224	-0.309
58.50	86.67	657.22	90.86	1.09E+08	7.36E-04	0.1518	-2.36E-03	-0.0178	-0.327
65.00	57.78	469.44	90.86	1.09E+08	7.70E-04	0.1994	-1.60E-03	-0.0129	-0.340
71.50	28.89	281.67	90.86	1.09E+08	7.92E-04	0.2534	-8.03E-04	-0.0078	-0.348
78.00	0.00	93.89	90.86	1.09E+08	8.03E-04	0.3135	0.00E+00	-0.0026	-0.350
84.50	-28.89	-93.89	90.86	1.09E+08	8.03E-04	0.3787	8.03E-04	0.0026	-0.348
91.00	-57.78	-281.67	90.86	1.09E+08	7.92E-04	0.4482	1.60E-03	0.0078	-0.340
97.50	-86.67	-469.44	90.86	1.09E+08	7.70E-04	0.5207	2.36E-03	0.0129	-0.327
104.00	-115.56	-657.22	90.86	1.09E+08	7.36E-04	0.5949	3.10E-03	0.0178	-0.309
110.50	-144.44	-845.00	90.86	1.09E+08	6.91E-04	0.6690	3.79E-03	0.0224	-0.287
117.00	-173.33	-1032.78	90.86	1.09E+08	6.35E-04	0.7413	4.43E-03	0.0267	-0.260
123.50	-202.22	-1220.56	90.86	1.09E+08	5.68E-04	0.8096	5.00E-03	0.0306	-0.230
130.00	-231.11	-1408.33	31.68	3.80E+07	7.26E-04	1.2926	5.72E-03	0.0348	-0.195
136.50	-260.00	-1596.11	31.68	3.80E+07	1.15E-03	2.6527	6.87E-03	0.0409	-0.154
143.00	-288.89	-1783.89	31.68	3.80E+07	8.59E-04	2.7727	7.73E-03	0.0474	-0.106
149.50	-317.78	-1971.67	31.68	3.80E+07	5.38E-04	2.8513	8.27E-03	0.0520	-0.054
156.00	-346.67	-2159.44	31.68	3.80E+07	1.85E-04	2.8795	8.45E-03	0.0543	0.000

$\Delta_{LL} := 0.350 \text{ in}$

$$\frac{J_{sp}}{\Delta_{LL}} = 445.7143$$

deflection is less than L/360
therefor okay for retrofit system

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Basement Girder:

$K_{LL} := 2.0$ *per IBC 1607.10.1*

$A_t := 13\ ft \cdot 56\ ft \cdot 3 = 2184\ ft^2$

$L_{o3} := 40\ psf \cdot 3 = 120\ psf$

$$L_3 := L_{o3} \cdot \left(0.25 + \frac{15\ ft}{\sqrt{K_{LL} \cdot A_t}}\right) = 57.2352\ psf$$ *adjusted live load for 3 floors based on IBC 1607.10.1*

$d_g := 7.75\ in$ $b_g := 7.75\ in$

$$S_g := \frac{{d_g}^2 \cdot b_g}{6} = 77.5807\ in^3$$

$\omega_{dl} := 10\ psf \cdot 3 \cdot 13\ ft = 390\ plf$

$\omega_{LL} := L_3 \cdot 13\ ft = 744.0581\ plf$

$L_{max} := 10\ ft$

$$M_{max} := \frac{(\omega_{LL} + \omega_{dl}) \cdot {L_{max}}^2}{8} = 14175.7263\ ft \cdot lbf$$

$$f_b := \frac{M_{max}}{S_g} = 2192.6671\ psi$$

$$V_{max} := \frac{(\omega_{LL} + \omega_{dl}) \cdot L_{max}}{2} = 5670.2905\ lbf$$

$$f_v := \frac{V_{max} \cdot 3}{2 \cdot d_g \cdot b_g} = 141.6098\ psi$$

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$F_b := 1050 \text{ psi}$ — *For SPF South Select Structural timbers > 5x5 used for beams and stringers*

$C_d := 1.00$ — *Use Cd=1.00 for consideration of normal live loads 2.3.2 NDS*

$C_t := 1.0$ — *Use will be Less than 150 degrees F sustained 2.3.3 NDS*

$C_L := 1.0$ — *beam is square as wide as it is deep and therefor has no need for bracing*

$C_f := 1.0$ — *depth <12" no adjustment*

$C_i := 1.0$ — *no incising*

$C_m := 1.0$ — *used in dry conditions*

$C_{fu} := 1.0$ — *not being used flat*

$F'_b := F_b \cdot C_d \cdot C_t \cdot C_L \cdot C_f \cdot C_i \cdot C_m \cdot C_{fu} = 1050 \text{ psi}$ — *2192 psi >> 1050 psi therefor strengthening req'd add'l posting req'd*

$M_{all} := F'_b \cdot S_g = 6788.3138 \text{ ft}\cdot\text{lbf}$

$L_{allowed} := \sqrt{\dfrac{M_{all} \cdot 8}{\omega_{dl} + \omega_{LL}}} = 6.92 \text{ ft}$ — *install lally column to reduce maximum span from 10 ft to 6.5 ft in basement*

$$V_u := \frac{L_{allowed} \cdot (\omega_{dl} + \omega_{LL})}{2} = 3923.8609 \text{ lbf}$$ *based on revised spacing of lally's*

$$f_v := \frac{V_u \cdot 3}{2 \cdot d_g \cdot b_g} = 97.9944 \text{ psi}$$

$F_v := 125$ psi *For SPF South Select Structural timbers > 5x5 used for beams and stringers*

$C_d := 1.00$ *Use Cd=1.00 for normal duration of live loads 2.3.2 NDS*

$C_t := 1.0$ *Use will be Less than 150 degrees F sustained 2.3.3 NDS*

$C_m := 1.00$ *joists are used in the dry - elevated moisture content is not a concern*

$$F'_v := F_v \cdot C_d \cdot C_t \cdot C_m = 125 \text{ psi}$$

Allowable Horizontal Shear stress is greater than applied horizontal shear stress therefor okay for Main Girder in shear