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The Floating Foundation Deck System Building Codes, Frost Heave Analysis, Structural Analysis

1. The Floating Foundation Deck System has been analyzed for a dead load of 12 psf, and a live load of 40 psf.
2. The Standard Building Code allows that building not exceeding one story in height and 400 sq. ft. do not need to meet the requirements for foundation extension below frost depth.
3. This structure is classified as a lightweight structure since the normal dead load bearing is less than 200 psf.
4. The National Building Code say that “except where erected upon solid rock or otherwise protected from frost, foundation walls, piers, and other permanent supports of all buildings and structures larger than 100 square feet in area or 10 feet in height shall extend to the frost line of the locality, and spread footings of adequate size shall be provided where necessary to distribute properly the load within the allowable load bearing value of the soil.”
5. The 2003 International Building Code states:
R403.1.4.1 Frost protection. Except where otherwise protected from frost, foundation walls, piers and other permanent supports of buildings and structures shall be protected from frost by one or more of the following methods:
 1. Extending below the frost line specified in Table R301.2(1);
 2. Constructing in accordance with Section R403.3;
 3. Constructing in accordance with ASCE 32-01; and
 4. Erected on solid rock.

Exceptions:

1. Freestanding accessory structures with an area of 400 square feet (37 m) or less and an eave height of 10 feet (3048 mm) or less shall not be required to be protected.
2. Decks not supported by a dwelling need not be provided with footings that extend below the frost line.

Footings shall not bear on frozen soil unless such frozen condition is of a permanent character.

R105.2 Work exempt from permit. Permits shall not be required for the following. Exemption from the permit requirements of this code shall not be deemed to grant authorization for any work to be done in any manner in violation of the provisions of this code or any other laws or ordinances of this jurisdiction.

Building:

1. One-story detached accessory structures, provided the floor area does not exceed 200 square feet (18.58 m).
 2. Fences not over 6 feet (1829 mm) high.
 3. Retaining walls that are not over 4 feet (1219 mm) in height measured from the bottom of the footing to the top of the wall, unless supporting a surcharge.
 4. Water tanks supported directly upon grade if the capacity does not exceed 5,000 gallons (18927 L) and the ratio of height to diameter or width does not exceed 2 to 1.
 5. Sidewalks and driveways not more than 30 inches (762 mm) above adjacent grade and not over any basement or story below.
 6. Painting, papering, tiling, carpeting, cabinets, counter tops and similar finish work.
 7. Prefabricated swimming pools that are less than 24 inches (610 mm) deep.
 8. Swings and other playground equipment accessory to a one or two-family dwelling.
 9. Window awnings supported by an exterior wall which do not project more than 54 inches (1372 mm) from the exterior wall and do not require additional support.
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6. The Deck System employing Dek-Block piers, 2x6 stringers and 2x6 decking has the flexibility and strength to safely support the design loads even with differential settlement of ½” between adjacent piers without damage to the structure. Supporting calculations are attached.
 7. The system has a plus or minus ½” tolerance in block height, and it is relatively easy to do maintenance shimming should settlement occur.

Frost Heave Analysis

Evaluate Settlement and Frost Heave

Structural Live Load - 40 PSF

Structural Dead Load - 12 PSF

$$W_L = 2.5 \times 40 = 100 \text{ PLF}$$

$$W_D = 2.5 \times 12 = 30 \text{ PLF}$$

Block = 51 Lbs.

$$DL = 174 + 51 = 225 \text{ PSF}$$

$$LL = 579 \text{ PSF}$$

Maximum Footing Load

$$= 579 + 174 + 51$$

$$= 804 \text{ PSF}$$

Calculate Simple Moments

$$M = \frac{.13 \times 4.92^2}{8} = .394$$

2x6

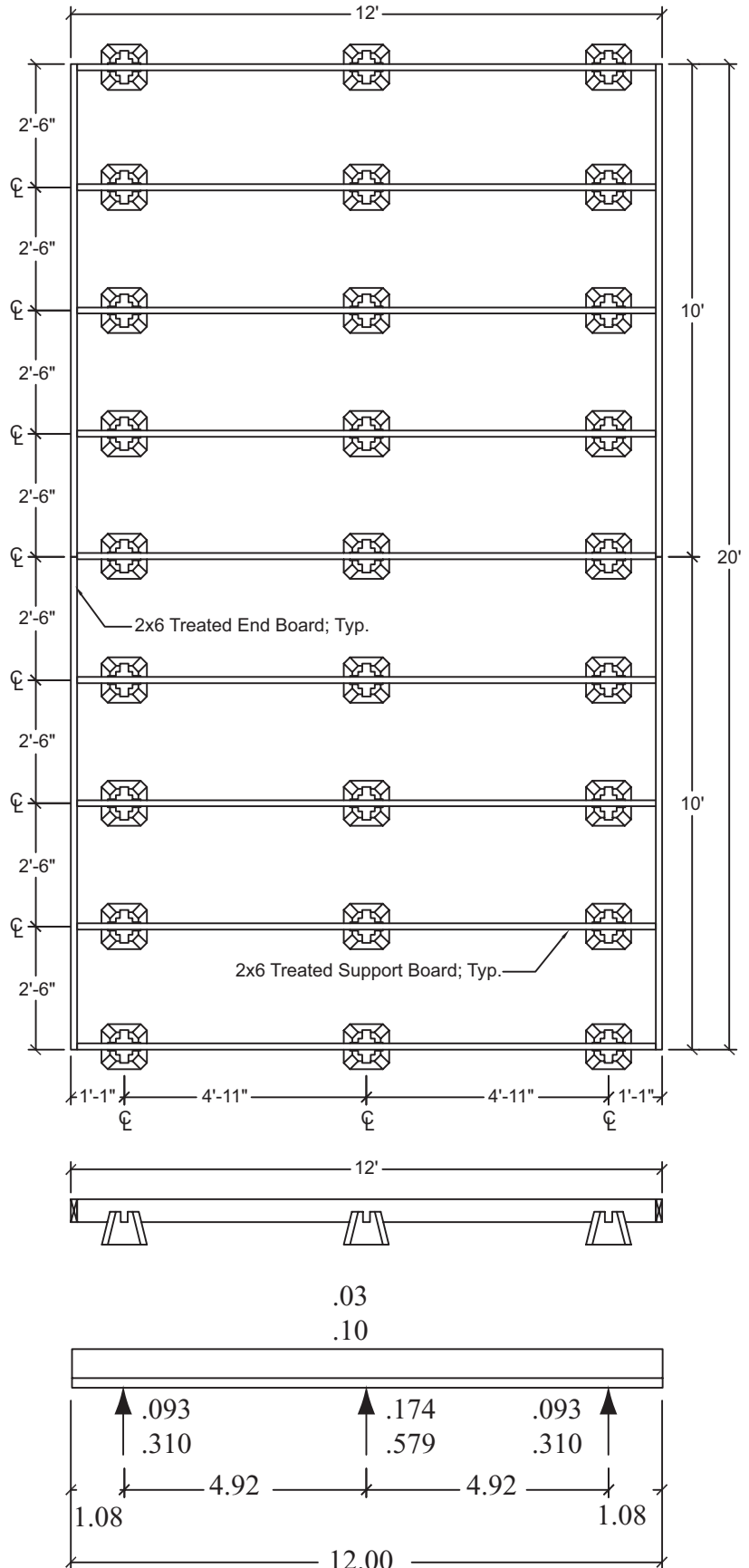
$$S = \frac{1.5 \times 5.5^2}{6} = 7.56$$

$$I = \frac{1.5 \times 5.5^3}{12} = 20.8$$

$$f_b = \frac{.394 \times 12}{7.56} = 625 \text{ psi}$$

Assume $E = 900,000$

$$\Delta = \frac{5 \times .13 \times 4.92^4 \times 12^3}{384 \times 900 \times 114} = .016 \text{ in}$$



Frost Heave Analysis

Assume that center support (block) settles 1/2"

Joist then spans 9.83 ft

Calculate Simple Moments

$$M = \frac{.13 \times 9.83^2}{8} = 1.57$$

$$f_b = \frac{1.57 \times 12}{7.56} = 2.49 \text{ ksi}$$

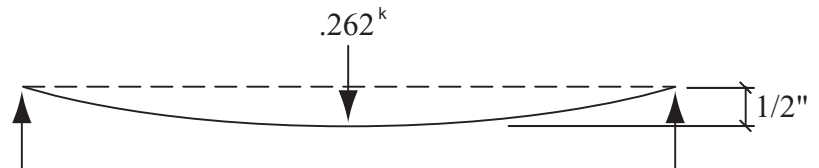
Assume E = 900,000

$$\Delta = \frac{5 \times .13 \times 9.83^4 \times 12^3}{384 \times 900 \times 20} = 1.51 \text{ in}$$

As support Settles or Heaves, the deck timbers will deflect to follow the support

$$\Delta = \frac{1''}{2} = \frac{Pl^3}{48EI} = \frac{P \times 9.84^3 \times 12^3}{48 \times 900 \times 20}$$

$$P = .262^k$$

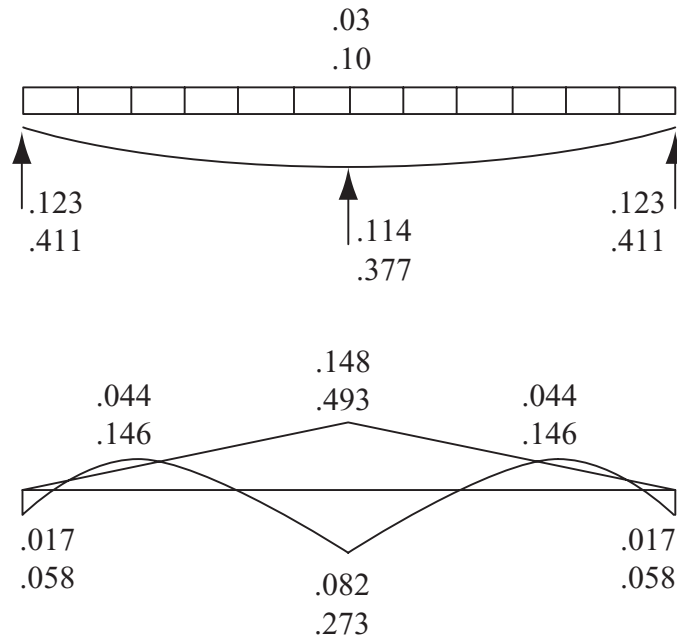


With center support deflected 1/2", the reactions and stresses are shown

At 1/2" Settlement

$$M = (.493 + .148) - (.082 + .273) = .286$$

$$f_b = \frac{.286 \times 12}{7.56} = .454 \text{ ksi}$$



Frost Heave Analysis

Check Deck Boards

Boards @ 6" O.C.

$$DL = 12 \text{ PSF}/2 = 6 \text{ PSF}$$

$$LL = 40 \text{ PSF}/2 = 20 \text{ PSF}$$

Calculate Simple Moments

$$M = \frac{.026 \times 2.50^2}{8} = .0203$$

$$S = \frac{5.5 \times 1.5^2}{6} = 2.07$$

$$I = \frac{5.5 \times 1.5^3}{12} = 1.55$$

$$f_b = \frac{.0203 \times 12}{2.07} = .118 \text{ ksi} \quad \text{O.K.}$$

Assume $E = 900,000$

$$\Delta = \frac{.026 \times 5 \times 2.50^4 \times 12^3}{384 \times 900 \times 1.55} = .016 \text{ in}$$

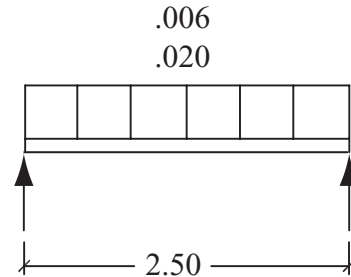
Assume 1/2" Settlement

$$\Delta = \frac{.023 \times 5 \times 5^4 \times 12^3}{384 \times 900 \times 1.55} = .232 \text{ in}$$

$$M = \frac{.026 \times 5^2}{8} = .0813$$

$$f_b = \frac{.0813 \times 12}{2.07} = .4713 \text{ ksi}$$

Deck boards are stiff enough to span over 5'-0" and have strength to span.



AE ASSOCIATES, INC.
*Engineering Design * Project & Construction Management*

BUILDING AND SPECIAL INSPECTIONS

January 16, 1997

To whom It May Concern:

Subject: DEKBRANDS Deck Systems-Building Code Reviews

AE ASSOCIATES, Inc. has been retained to consider the DEKBrands Deck System. Included in this process was structural design analysis of components that make up the system, including the Dek-Block Pier footing members, the spacing of these blocks, deck wood stringers, joists and surface decking.

In order to make these design analyses it was reasonable to use established design standards for vertical loading and ground support, as provided for in the various Building Codes adopted by all states and other municipalities. Where these Codes did not provide for specific "deck" loading criteria residential interior loads were used. All Code revisions since 1985 have been reviewed to determine that all current provisions were being complied with. These standards are summarized below, by Code and the most applicable Code chapter or section:

Council of American Building Officials (CABO)

Buildings - section 202

Design Criteria - sections 301.3, 301.4, 301.6, Table 301.4, 315.3

Foundations - sections 401.2, Table 401.4.1, Table 502.3.1a

Uniform Building Code (ICBO)

Foundations - chapter 18, sections 1803.2, 1804.1.1,

1806.1, 1806.3, 1806.5, 1806.7.2.3, 1806.7.4, Table 18.1.A

Structural forces - chapter 16, sections 1602, 1603.3.1,

1604.1, 1604.2, 1604.3, 1606, 1607, 1608, Table 16-A

Size and Height - chapter 5, section 509.1, 509.2, 509.3,

chapter I, section 106, 106.2(2)(2.1), 106.2(2)(2.7)

Standard Building Code (SBCCI)

Egress - Chapter 10, section 1014.1.1, 1014.1.2, 1015.1
Structural Loads - chapter 16, section 1601.2.1, 1601.2.2,
1601.5, 1603.1, 1604.1, Table 1604.1, 1604.3
Foundations - chapter 18, section 1804.3.3.1, 1804.4.1,
chapter 23, section 2303.2.1, 2303.2.2
Floor Construction - Wood - chapter 23, section 2301.1.2,
2301.2.1, 2301.2.5, 2301.3, 2303, 2304.2, 2306.1, 2307
(general)

Building Officials and Code Administrators International (BOCA)

Loadings - section 1606.1, 1606.2, table 1606, 1606.3
Footings - section 1807.1, 1810.3.1

In addition the "Dwelling Construction under the Uniform Building Code" handbook was consulted , particularly chapters on framing, foundations and tables on wood member working stresses.

The subject deck footing and structural systems were designed to a minimum standard of 40 pounds per square foot of LIVE LOAD, a CONCENTRATED LOAD of 300 pounds, using a DEAD LOAD of 12 pounds per square foot. All Code requirements considered appropriate are complied with using these standard. These are also considered conservative load ratings since higher live load values (up to 75 pounds per square foot) could be used under conditions where soil and wood member strength ratings other than "minimum Code" values used.

We certify that, after review of all applicable current Codes, all systems and components analyzed by this company meet or exceed Code standards for uniform and concentrated loadings plus soil bearing conditions, when these products are installed in accordance with the instructions. Local Building Officials may apply requirements based on specific conditions of their municipality, requiring the consumer to purchase a building permit for the installation.

Respectfully submitted,

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		Job Name	S.O. No		
			EST. 90-14		
Description					
REVIEW - PRO-SHOP DECK SYSTEMS					
Design By:	Date	Checked By	Date	Approved	Date
					4/6/90

REF: PROSHOP PLANS FOR STANDARDIZED DECKS
 (ATTACHED)



ISSUE:

IS 2X6 (TYP.) DECKING OK, RELATIVE TO STRESS
 4 DEFLECTION, WHEN PLACED ON JOISTS AS MUCH AS
 30" O.C. (I.E. SPAN OF 28 1/2")

LOADING PATTERNS:

- 40 PSF L.L - UNIFORM
- 300 LB CONCENTRATED LOAD ON 12" X 12" AREA

ACCEPTANCE CRITERIA:

- STRESS, BENDING (EXTREME FIBER) <
- DEFLECTION L/E > 360
- BOTH ARE ACCEPTED LEVELS FROM UBC

ASSUMPTIONS:

STANDARD & BETTER LUMBER INSTALLED TO
 REASONABLE
 CONSTRUCTION QUALITY. USE SUPPORTED EDGES
 SINCE SOME DECK BOARD ENDS WILL BE INSTALED
 AT JOISTS.
 1/2" MAXIMUM GAP BETWEEN BOARDS

FROM UBC:

- MIN. $t\beta = 475$ psi (LOWEST IN UBC)
- MIN. $E = 700,000$ psi (LOWEST IN UBC)*

SECTIONS:

$$\begin{aligned} \text{SECT MODS} &= th^2/6 \text{ (2X6)} \\ &= 2.1 \text{ in}^3 \\ I &= 1.55 \text{ in} \end{aligned}$$

ALSO:

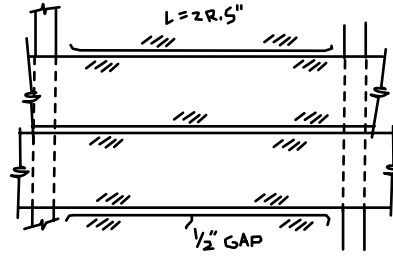
- L= 28.5"
- D.L. ~ 2.4 LBS/FT OF 2.6

L.L.

40#/FT ==> 20#/FT OF 2X6

300#/12" ==> 150# Per 12" of 2X6

D.L. = 2.4 #/FT



STRESSES:

UNIFORM LOADING: (ONE 2X6)

$$17 = WL/8 \\ = 190 \text{ IN-LB}$$

$$W = (20 + 2.4) 28.5"/12" \\ = 53.2 \#$$

$$t\beta = 190 \text{ IN-LB}/2.1 \text{ IN}^3 \\ = 90 \text{ psi} \ll 475 \text{ psi OK!}$$

CONC. LOADING:

SEE ROARK, 5th P. 107, CA 14

$$a = 8.25"$$

$$c = 12"$$

$$d = 14.25"$$

$$W \sim 154\#$$

$$\text{MAX. } M = W d/L (a + cd/2L)$$

$$= 866 \text{ in-lb}$$

$$t\beta = 413 \text{ psi} \ll 475 \text{ psi OK!}$$

DEFLECTIONS:

UNIFORM LOADING:

$$E = 5/384 WL^3/EI \text{ LET } E=900,000 \text{ psi}$$

$$= .012" \Rightarrow L/E = 2479 \gg 360 \text{ OK!}$$

CONC. LOADING:

$$W = 154\#$$

$$E = 1/48EI \{ 8R1 (X^3 - L^2X) + WX [8d^3/L - 2bc^2/L + c^3/L + 2c^2] \\ - 2W (x-a) /c \}$$

$$\text{WHERE: } X = L/2 \quad R1 = W/2$$

$$E = 1/48EI \{ -WL^3/2 + WL/2 (1077.5) - 2W(108) \} \\ = .023"$$

$$L/E = 1245 \gg 360 \text{ OK!}$$

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