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Agriculture
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Engineering Research Service

REPORT NUMBER: 589

August 1976

Driven Post Foundation

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Contribution No. 589, from Engineering Research Service, Research Branch, Canada Agriculture, Ottawa, Ontario K1A 0C6.

Driven Post Foundations

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1.0 Introduction

This paper provides design information for using short driven posts to support a timber grade beam foundation. The beam consists of two planks well above grade and notched into the top of the posts, with pressure treated tongue-and-groove splash planking to below grade. This planking can be nailed to the inside or outside face of the posts. Several building types such as stud wall, rigid frame, or arch rafter could then be fastened to the top of this beam. A typical post and plank arrangement is shown in Fig. 1.

This type of construction does not require concrete, reduces the risk of bad weather during construction and can be done with only a tractor-mounted post-hole auger and fence post driver. The merits of augering a hole 2 to 4 ft deep prior to driving the post will be discussed later in this paper.

2.0 Theory

The vertical load capacity of a driven post can be based on the Hiley formula, currently used by the Canadian Institute of Timber Construction.

This estimates driving conditions and the design capacity of timber piling when loads do not exceed 30 tons per pile. The formula is:

$$R = \frac{4\ n\ W\ H}{s + \frac{c}{2}} \text{, where}$$

R = allowable load on the pile or post (lb)

n = efficiency of the hammer blow

W = weight of the hammer (lb)

H = height of free fall of the hammer (ft)

s = average penetration per blow for the last five (5) blows (in/blow)

c = temporary elastic compressions of post, ground and driving head (in).

The efficiency of the blow n is:

$$n = \frac{W + e^2 P}{W \quad P} \text{, where}$$

P = weight of the post (lb)

e = coeff. for iron hammer on wood (0.25)

Typically, for a 200-lb hammer and a 5-in diam. post 7 ft long weighing 30 lb/ft^3, the efficiency of the blow would be 0.88.

The temporary elastic compression c is:

$$c = 3R\frac{L}{A_1 E} + \frac{0.00014}{A_2} \text{, where}$$

L = post length (in)

A_1 = cross sectional area of the post at mid-length (in^2)

A_2 = bearing area of the small end of the pile (in^2)

E = modulus of elasticity of the post (lb/in^2)

Note that the parameter c in this paper is incorporated in the design chart (Fig. 2) and does not need to be calculated directly by the user. For further information on use of the Hiley formula, see "Pressure Treated Timber Piles" published by the Canadian Institute of Timber Construction, Ottawa.

Standard strength of materials theory was used to determine the bending and shear capacities of the grade beam, for both vertical and lateral loads. Table 1 gives the allowable vertical wall load for various beam constructions. Longitudinal shear in the grade beam is usually critical; do not interpolate.

To evaluate the allowable lateral load, consider soil strength, pier strength, and grade beam lateral strength to establish which factor is critical. Table 2 gives allowable lateral loads based on soil strength while Table 3 gives allowable lateral load based on post strength. The values in Tables 2 and 3 are based on values in "Pole Building Design" published by American Wood Preservers Institute, Washington, D.C., U.S.A.

The lateral strength of the grade beam is given in Table 4. As noted at the bottom of the table, an adequate connection must be made between the post and the stud above it to resist a lateral force of the bottom wall lateral load (lb/ft) times the stud spacing (ft).

3.0 Augering before driving

For very firm soils or dry surface conditions, the posts may be hard to drive, and may develop sufficient vertical resistance before they have penetrated far enough to resist frost action. A solution is to auger a post hole 2 to 4 ft deep, then start driving the post into the bottom of the hole. This requires a longer post, but embedment is deeper, this is recommended to reduce the risk of frost action as well as place the driven part of the post in deeper soil that is more consolidated and less affected by changing moisture conditions. The lateral resistance of the post is also increased with depth.

4.0 Nailing

Nailing of beams and splash planking to posts is based on 5-in spiral nails penetrating 3 inches into posts Group El or better. The allowable load per nail including adjustment for low hazard and snow load duration is 146 lb per nail. Allowable loads in the last column of Table 1 are based on 4 nails per post per row of 2 x 6 inch splash planking. It is obvious that except in the case of very light loads, nails will not be sufficient to transmit the vertical loads from the grade beam to the post. Notching of the posts, so that the grade beam members on edge act in bearing at the posts, is required.

The wall sill should be nailed with six or eight 5-in nails per post for a 2 x 6 in or 2 x 8 in sill respectively (Fig. 1). The sill should also be nailed to the beam members with 3½-in nails 12 in o.c. except within 2 ft of posts where spacing should be reduced to 6 in o.c. Use all hot-dipped galvanized nails for corrosion resistance close to grade.

Where horizontal girts are used and thus all the lateral load is transferred at the post, an adequate connection detail must be devised using, for example, metal straps or joist hangers.

5.0 Notching

As pointed out in the preceding section, since nails are in most cases insufficient to transfer the vertical load from the beam to the post, the posts must be notched to allow the beam members to act in bearing at the posts.

Posts may veer off line during driving, therefore notching the posts will provide good beam alignment and greater nailing area.

If two beam members on edge are used, then both sides of post should be notched. It is recommended that a minimum 3-in of post remain between notches (Fig. 1).

6.0 Example

Building 34' x 64'
Trusses 4' o.c., slope 4:12
Wall 8' high (above 18" splash planking)
studs 2, o.c.
with interior knee braces.
Location - Saskatoon - Ground snow load 35 psf
1/10 hourly wind pressure 7.5 psf.
Allowable soil bearing pressure 2500 psf.

Average vertical wall load:

Snow load coeff. = 0.6
Dead Load (assumed) roof - 4.2 psf
wall - 2.5 psf

Therefore average vertical wall load is:

$$(0.6 \times 35 \times \frac{34}{2} + \frac{34}{2} \times 4.2 + 8 \times 2.5$$

$$= 357 + 71 + 20$$

$$= 448 \text{ lb/ft}$$

Average lateral wall load:

from NBCC 4.1.6.1

$$p = q\ Ce\ Cg\ Cp$$

where p is the design external pressure and C's are pressure coefficients

thus $p = 7.5 \times 1.0 \times 2.0 \times Cp$

If we considered the windward wall, then

$$C_p = 0.7$$

$$\text{then} \quad p = 7.5 \times 1.0 \times 2.0 \times 0.7$$

$$= 10.5 \text{ psf}$$

The average lateral wall load then becomes 8 x 10.5 = 84 lb/ft.

From Table 1, in order to utilize posts 8 ft oc, a grade beam of 1-2" x 8" plank on edge plus 3 rows of 2 x 6" splash planking, giving a total vertical load carrying capacity of

$$\frac{442}{2} + 3 \times 91 = 494 \text{ lb/ft}$$

would be sufficient to carry the design load of 448 lb/ft.

From Table 4, it is seen that for posts 8 ft o.c., studs 2 ft o.c., and a lateral load of 84 lb/ft, a 2 x 6 in member on the flat with a capacity of 148 lb/ft would be required as the wall sill.

The lateral and vertical loads on the post are now 8 x 84 = 672 lb and 8 x 448 = 3584 lb respectively.

It is now necessary to check the post capacity. A 6 in min. diameter post is used in order to provide nailing space. Table 3 indicates that a 6 in diameter post up to 2 ft above the ground can support the design lateral load of 672 lb up to approximately 8 ft for 18 in splash planking.

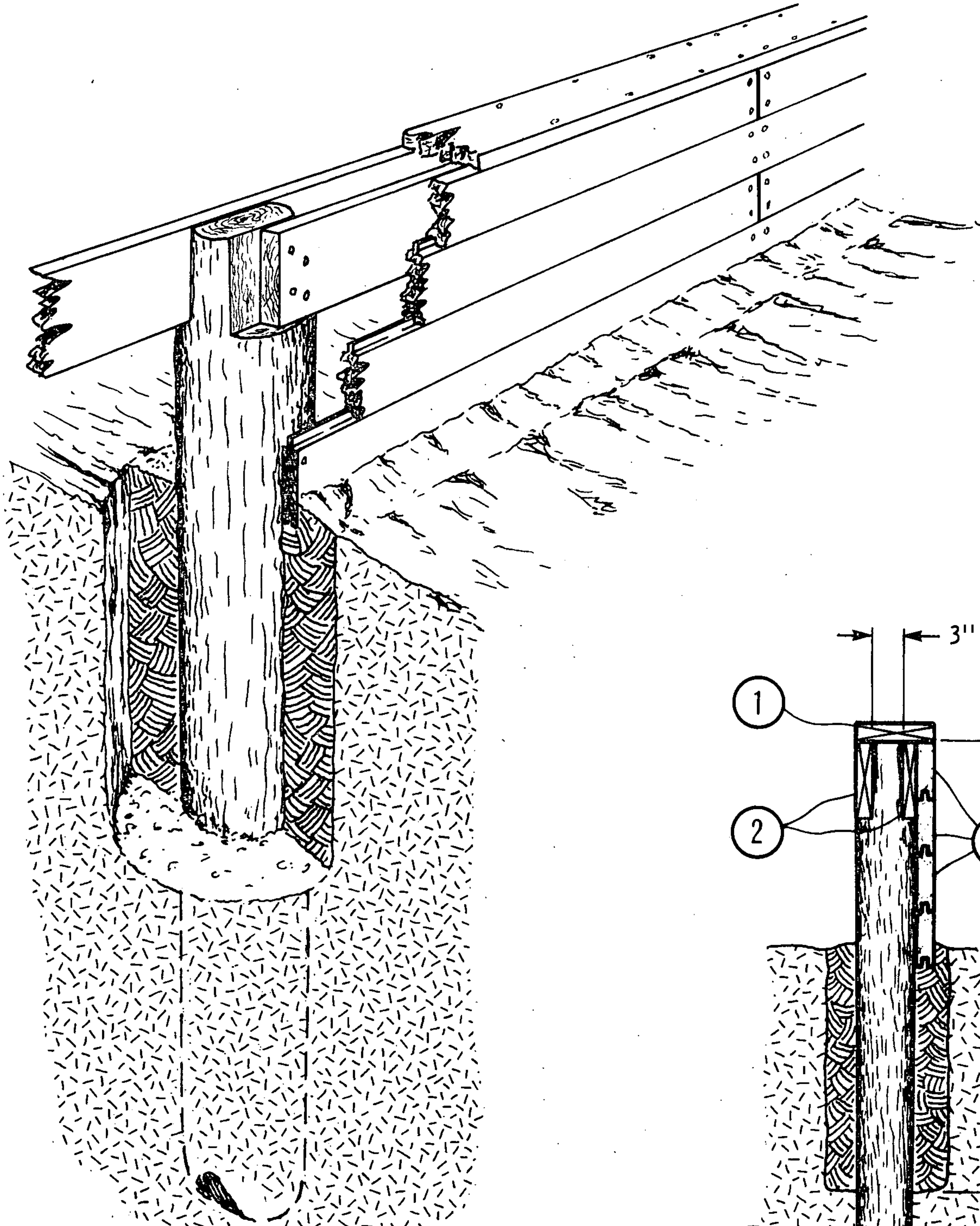
From Table 2, it is found that for a 6 in post in a soil with a bearing strength of 2500 psf, a total depth of 4 ft provides a lateral load capacity of $540 \times \frac{2500}{1000} = 1350$ lb. This is more than adequate for the design load of 672 lb.

Thus, it is established that the lateral load capacity of the foundation is limited by the 2" x 8" beam member on the flat.

Proper driving of the posts is established on a trial basis. If, for example, 7 ft posts are driven in holes preaugered to a 2 ft depth, then using Fig. 2, assuming W = 200 lb, H = 4 ft, and required vertical load capacity R = 3584 lb, then $\frac{17.6\ WH}{R} = 3.9$ and the maximum 5-blow total penetration allowable is approximately 3.7 inches. If the penetration is less, then adequate strength has been developed; if the penetration is greater than 3.7 in per 5 blows, then further driving is necessary. Of course, as the post is driven, the parameter H changes, therefore the value of H used in factor $\frac{17.6\ WH}{R}$ must be the value measured at the same time that penetration measurements are taken.

If resultant post penetration required for vertical load carrying capacity is much less than that required for lateral loads and frost heaving, (indicating difficult driving and greater vertical strength than required), then holes should be preaugered to a greater depth.

A total depth, including preaugered depth, of at least 4 ft is preferred.



1 wall sill, 2"x 6" or 2"x 8"; nailed to (2) & (4)
2 beam members, 2"x 6" or 2"x 8"; nailed to (4)
3 splash planking, 2"x 6", pressure treated; nailed to (4)
4 pressure treated driven post, notched for (2)
5 height of sill above ground
6 auger hole, depth variable
7 total depth, 4' minimum

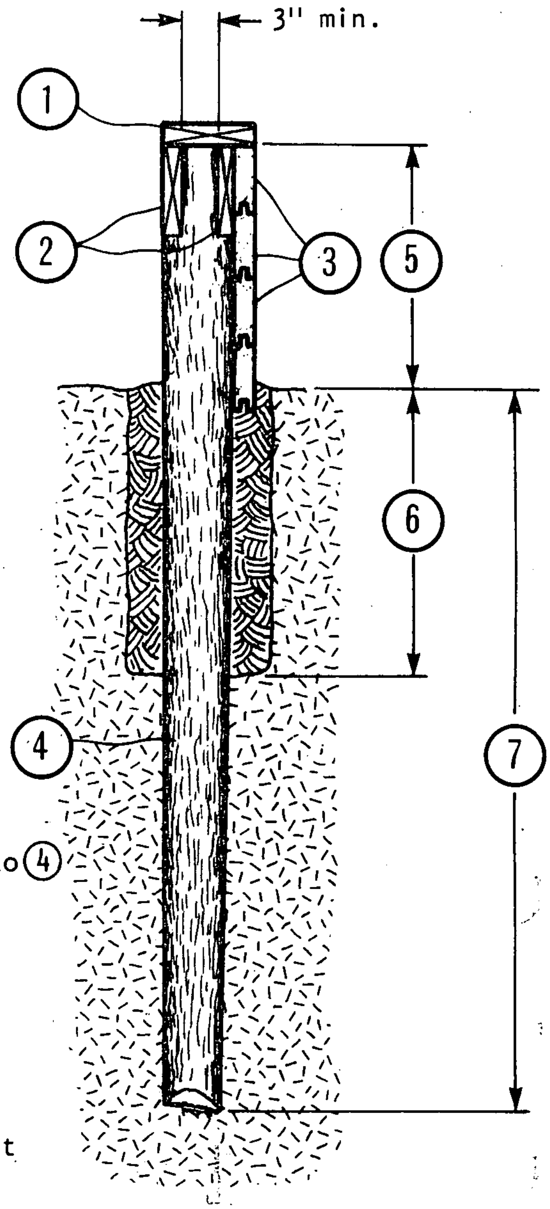


Figure 1. Typical grade beam and driven post construction

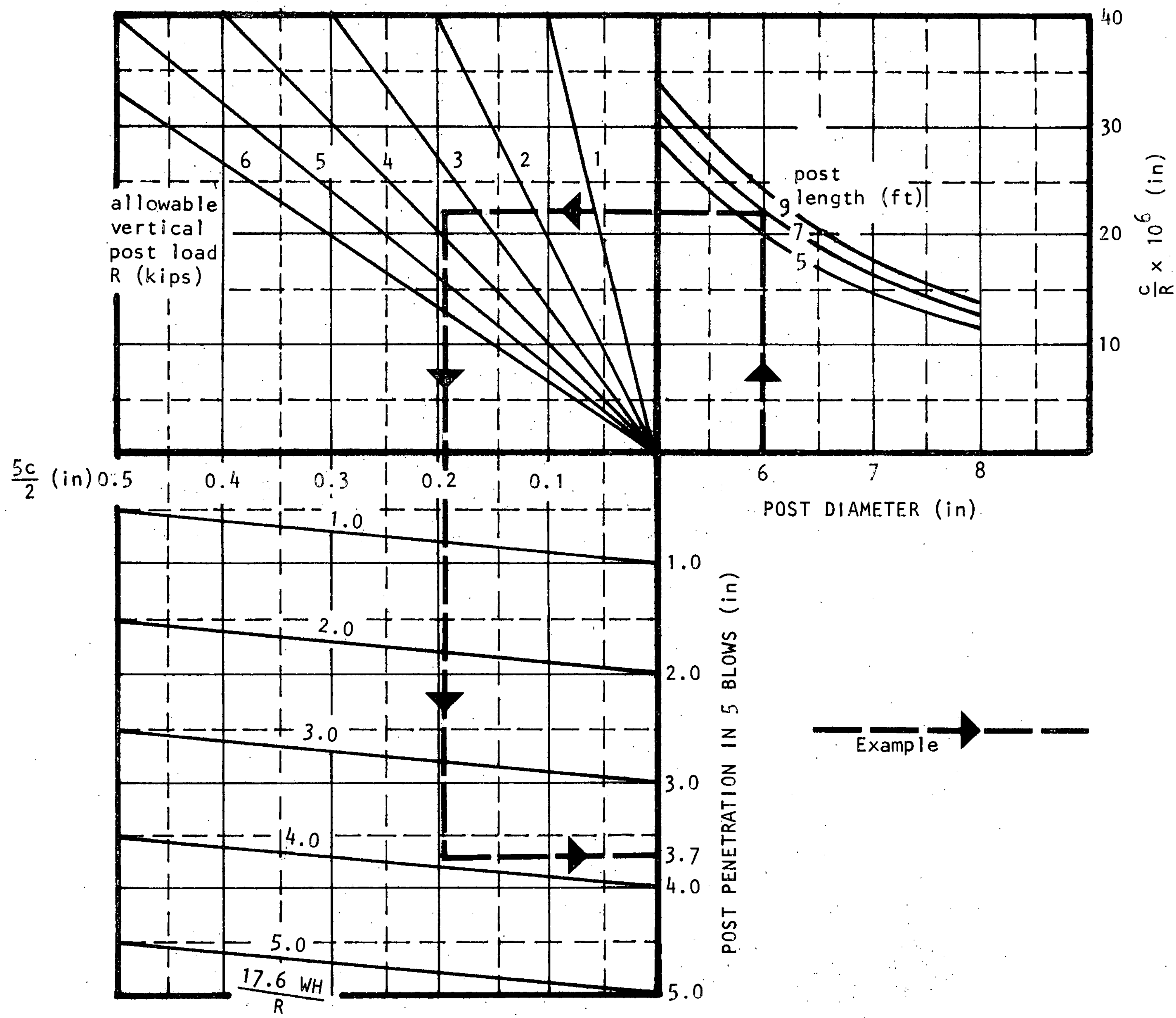


Figure 2. Chart for determining post vertical load capacity based on driving conditions

TABLE 1. Average vertical load capacity of grade beam and splash planking (lb/ft)[a]

Post Spacing (ft)	Truss Spacing (ft)	Beam Construction	load capacity of beam (lb/ft)	load capacity per row 2 x 6 splash planking (lb/ft)
8	4	2-2 x 8	442	73
	4	2-2 x 6	256	
	2	2-2 x 8	416	73
	2	2-2 x 6	256	
4	4		(b)	(b)
	2	2-2 x 8	1248	146
		2-2 x 6	946	

(a) Based on No. 2 Spruce or better.
(b) For this arrangement, vertical loads transferred directly to posts.

TABLE 2. Allowable lateral load (lb) on posts per 1000 psf allowable soil bearing pressure[a]

Total post depth (ft)	Post diameter (in) 5	6	7	8
4	430	540	630	720
6	769	923	1076	1231
8	1100	1320	1540	1760

(a) Based on height of sill above ground of H = 2 ft. For H = 3 ft, decrease allowable load by 15%, for H = 1 ft increase allowable load by 15%.

TABLE 3. Allowable lateral load (lb) on posts based on post bending strength[a] [b]

Total post depth (ft)	Post diameters (in)			
	5	6	7	8
4	455	786	1249	1865
6	378	654	1039	1551
8	324	560	889	1328

[a] Based on allowable bending stress of 900 psi.

[b] Height of sill above ground assumed to be H = 2 ft. For H = 1 ft, increase allowable loads by 30%, for H = 3 ft, decrease allowable loads by 20%.

TABLE 4. Average lateral load capacity of grade beam (lb/ft)[a]

Post Spacing (ft)	Wall sill	lateral load capacity (lb/ft)
8[b]	2 x 8	241
8	2 x 6	148
4	2 x 8	723
4	2 x 6	549

[a] Based on No. 2 Spruce or better.

[b] If horizontal girts used then total lateral load is resisted at post and adequate connection to sill and post must be used.