

Perma-Column Deck Post Design Manual

*DP4430, DP4440, DP4640, DP6630, DP6640, DP6430, and DP6440
models*



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1. Deck Post Design Overview

The Perma-Column Deck Post is designed to support wood decks, porches or other similar structures, and is intended to be used as an alternative to embedded wood posts and cast-in-place concrete piers. This manual contains drawings and descriptions for seven (7) Deck Post models; a chart showing allowable shear, uplift and gravity load capacities; and discussion of design assumptions. Each Deck Post assembly consists of a reinforced concrete column designed in accordance with The American Concrete Institute (ACI) and an epoxy powder coated steel bracket designed in accordance with The American Institute of Steel Construction (AISC). The structural analysis of foundation, steel brackets, and steel-to-wood connections was performed using the allowable stress design (ASD) methodology, while the design of the reinforced concrete column utilized load and resistance factor (LRFD) design methodology divided by 1.6 to convert from LRFD to ASD.

2. Deck Post Description

The Deck Post is a 10 ksi pre-cast reinforced concrete column with a steel structural reinforcing bracket (SRB). The SRB consists of a "U" shaped bracket at the top welded to #4 vertical reinforcing bars, and a piece of ½" pipe size tubing (PST) near the bottom, also welded to the vertical rebar. The rebar is weldable A706, grade 60 steel. The ½" PST is positioned approximately 2-1/4 inches from the base of the column and provides an opening through which to insert uplift resisting attachments. 2"x2"x8 ½" steel uplift angles fastened with a ½" through bolt, or a #4 horizontal reinforcing bar inserted through the post can be used for wind uplift resistance.

The dimensions for the seven models are given in Table 2.1. The DP4430, DP4440 and DP4640 models are to be used with 4x4 nominal wood posts or 3-1/2" wide wood beams, the DP6630 and DP6640 models are to be used with 6x6 nominal wood posts or 5-1/2 inch wide wood beams, and the DP6430 and DP6440 models are to be used with 6x6 full size wood posts or 6" wide wood beams. The DP4430, DP4440 and DP4640 are reinforced with one #4 rebar centered and continuous through the entire column length. The DP6630, DP6640, DP6430 and DP6440 are reinforced with two #4 rebar positioned in a "V" shape with it's vertex near the bottom of the column. Please note that every model may not be stocked in all areas, check with your Deck Post supplier. The "Minimum Embedment" depth column in Table 2.1 ensures that the top of the concrete column projects above ground a maximum of ten (10) inches; see also Section 2: Deck Post Design and Section 9: DP Extender in this manual.

TABLE 2.1: DECK POST DESCRIPTION					
Model ID	Width (in)	Depth (in)	Length (in)	Minimum Embedment (in)	Reinforcement
DP4430	3-5/8	3-1/2	30	20	(1) #4 Rebar
DP4440	3-5/8	3-1/2	40	30	(1) #4 Rebar
DP4640	3-5/8	5	40	30	(1) #4 Rebar
DP6630	5-5/8	5	30	20	(2) #4 Rebar
DP6640	5-5/8	5	40	30	(2) #4 Rebar
DP6430	6-1/8	5	30	20	(2) #4 Rebar
DP6440	6-1/8	5	40	30	(2) #4 Rebar
<i>Note: Every model may not be stocked in all areas, please check with your Deck Post supplier.</i>					

3. Steel Bracket Design

The forces applied from a wood deck, or similar structure, to the “U” shaped steel bracket are a vertical uplift force, a downward gravity force, and a horizontal shear force. The wood beam or column should have direct bearing on the bottom to transfer axial loads directly to the concrete deck post. The steel bracket is assumed to have no moment capacity. The dimensions and physical properties for the steel brackets are given in Table 3.1. All mechanical fasteners are to be installed as per the manufacturer’s recommendations and this design manual. Each steel bracket is made of 1/8” thick ASTM A36 steel welded with 1/8” E70 fillet weld all around. The DP4430 and DP4440 brackets have four holes for #17 x 2 inch grade 5 galvanized wood screws on each side, staggered; the DP4640, DP6630, DP6640, DP6430, and DP6440 brackets have five holes on each side, also staggered. The analysis of the uplift capacity of the steel brackets includes tension, bending, block shear, and bracket to rebar connection checks.

TABLE 3.1: STEEL BRACKET DESCRIPTION					
Model ID	Pocket Width (in)	Length (in)	Height (in)	Bracket Thickness (in)	Total Number of Holes (in)
DP4430	3-5/8	3-1/2	5	1/8	8
DP4440	3-5/8	3-1/2	5	1/8	8
DP4640	3-5/8	5	7	1/8	10
DP6630	5-5/8	5	7	1/8	10
DP6640	5-5/8	5	7	1/8	10
DP6430	6-1/8	5	7	1/8	10
DP6440	6-1/8	5	7	1/8	10

4. Deck Post Design

The allowable uplift, gravity, and shear capacities presented in this manual are determined based on a twenty (20) inch minimum grade to top of footing dimension for DP4430, DP6430 and DP6630 models and thirty (30) inch minimum grade to top of footing dimension for DP4440, DP4640, DP6640 and DP6440 models. The tensile strength of a column is defined by the tensile strength of reinforcement bars and their top and bottom weld connections to adjacent components. Only uplift, gravity, and shear forces are considered in this analysis. The steel bracket is not designed to resist bending moments, however, the internal bending moments resulting from a shear force applied at top of column ten (10) inches above grade are considered in the design. The effect of internal combined axial and bending loading is insignificant and is not considered in this analysis. The minimum embedment requirements for each of the models ensures that the projection of each column above grade is equal to or less than ten (10) inches. It is important to note that the maximum dimension of ten (10) inches from grade to top of concrete column is a prerequisite used in vertical, uplift and shear calculations in this manual. If this dimension is exceeded so that the column embedment depth is less than the minimum embedment depth specified in the Table 2.1, the tabulated vertical, uplift, and shear capacities of the Perma-Column Deck Post provided in this manual are not applicable.

5. Wood Connection Design

The wood beam or column is assumed to have a specific gravity of 0.36 or greater and is fastened to the steel bracket with #17 x 2" grade 5 galvanized wood screws. All metal components, including steel bracket and screw fasteners, shall be suitable for treated wood applications. The wood to steel connection was analyzed as per the National Design Specification for Wood Construction, 2005 edition, by the American Forest and Paper Association. The NDS adjustment factors are as follows:

Load Duration Factor	$C_D = 1.6$
Wet Service Factor	$C_M = 0.7$
(All other factors = 1.0)	

A barrier membrane between the pressure treated wood post or beam and the steel bracket is not necessary. The steel bracket is protected by the Perma-Column EpoxyZirc Coating pretreatment, a process in which Zirconium molecules chemically crystallize the steel molecules, effectively changing the surface of the steel into a compound that does not oxidize. The ASTM B-117 Salt Spray Testing results show that the Perma-Column EpoxyZirc Coating outperforms the G185 galvanized coating, which is thicker than the galvanized coating prescribed by the ASTM A653.

The Perma-Column Deck Post can be used as an alternative to cast-in-place concrete piers and embedded wood posts that are incorporated in code-approved prescriptive specifications. Wood member sizes, connections, post spacing, footing size, lateral bracing and height limitations of the structure shall follow the prescriptive code requirements. For construction that falls outside the prescriptive code limitations, the Deck Post shall be part of an engineered design.

6. Foundation Design

The foundation is designed in accordance with ASAE EP486.1, Shallow Post Foundation Design by the American Society of Agricultural Engineers using the following design parameters:

• Initial Allowable Vertical Soil Pressure, S_v	2000	psf
• Initial Allowable Lateral Soil Pressure, S	200	psf
• Adjusted Allowable Lateral Soil Pressure, S'	532	psf
• Required Post Embedment, d	see Table 2.1	
• Concrete Collar Width, w	see Table 8.1	
• Concrete Collar Thickness, t_c	see Table 8.1	
• Footing Width, t_w	see Table 8.1	
• Footing Thickness, t_f	see Table 8.1	
• Soil Density, α	105	pcf
• Soil Friction Angle, q	26	degrees

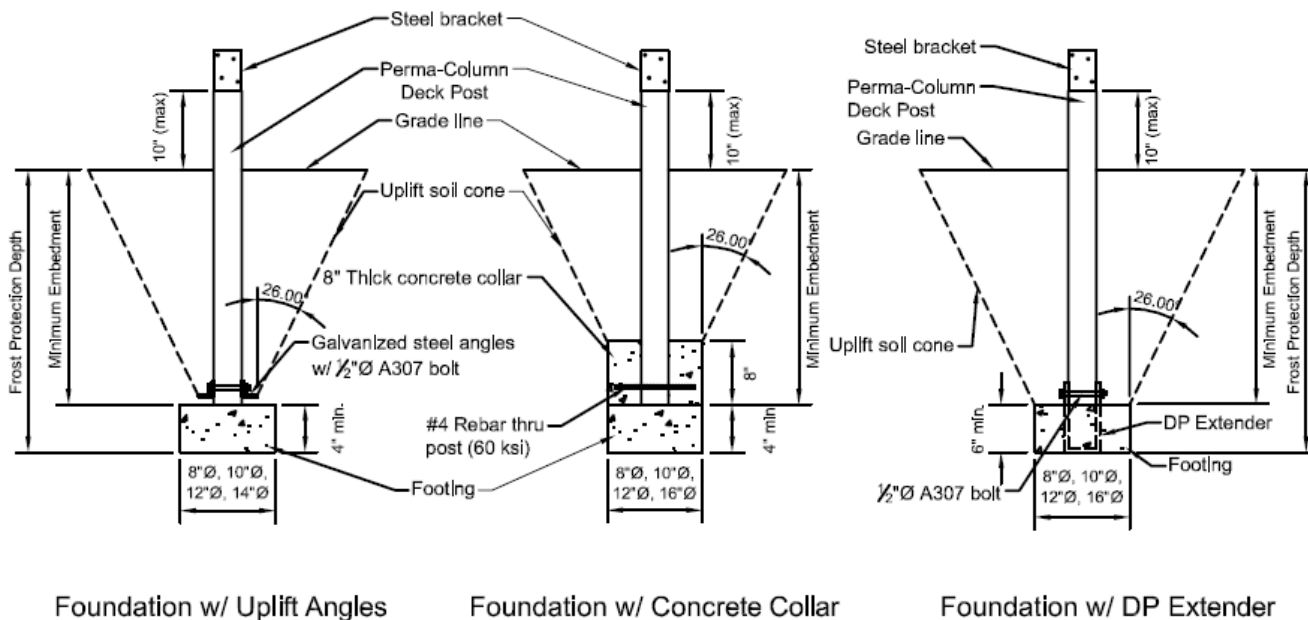


Figure 6.1: Foundation Details

ASAE EP486.1 is referenced in the International Building Code (IBC). The initial allowable vertical soil pressure is measured at 12 inches below grade. Per the EP486.1 Table 1, Footnote 4, the adjusted allowable vertical soil pressure is increased by 20% for each additional foot of depth up to three times the initial allowable vertical soil pressure. The diameter of precast footing pads is 2" smaller than the diameter of the foundation hole while the diameter of a cast in place footing is equal to the diameter of foundation hole. The allowable vertical capacity of a footing is calculated based on the size of footing and not the size of the hole.

The allowable shear capacity is calculated using the EP486.1 formula for a non-constrained shallow post foundation without concrete collars. Though a concrete collar may be present, its contribution to the lateral resistance is insignificant and is conservatively ignored. The thickness (height) of a concrete collar is intentionally limited to eight (8) inches so as to increase the uplift resistance of the system. Increasing the thickness of a concrete collar will reduce the dimension between top of concrete and grade, resulting in reduced size of uplift soil cone and reduced allowable uplift capacity. Thickness of a concrete collar may be increased only by increasing the embedment depth of the deck post such that the dimension between top of concrete collar and grade remains unchanged.

The uplift resistance is provided by the weight of the concrete collar, if present, and by the weight of the soil cone, see Figure 6.1. The size and weight of the soil cone is calculated using the design parameters described above. The tabulated allowable capacities are only applicable to footings installed as described in this manual.

Uplift resistance can be achieved by any of the following methods:

- Steel uplift angles (see Figure 6.1)
- Concrete collar with rebar inserted through column (see Figure 6.1)
- DP Extender (see Figure 6.1)
- Molded Plastic FootingPad (see Figure 9.1)

A foundation with compacted soil backfill may use two L2 x 2 x 1/8 x 8-1/2" ASTM A36 hot-dipped galvanized steel angles to provide uplift resistance, one angle on each side of the concrete post. The steel angles are

attached with one ½" diameter ASTM A307 bolt. To locate and analyze the areas of high stress concentration, an angle was modeled in Visual Analysis, a structural analysis and design software package, see Figure 6.2. As uplift forces act on the column, vertical resistance is provided by the soil cone above causing bending in the uplift angles. The steel angles are designed in accordance with the procedures outlined in the Manual of Steel Construction by AISC.

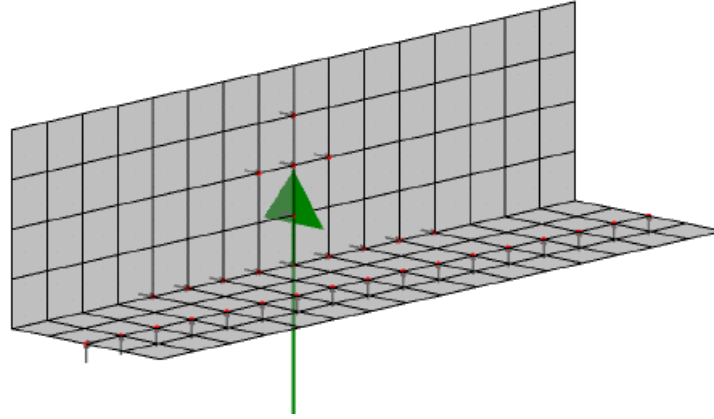


Figure 6.2: Analog Model of One L2 x 2 x 1/8 x 8-1/2" Angle, IES Visual Analysis 8.0

The minimum frost depth and footing thickness requirement is determined by local authorities and is outside of the scope of this manual. The DP4430, DP6430 and DP6630 models embedded twenty (20) inches with a four (4) inch thick footing provide twenty-four (24) inches of frost protection, while DP4440, DP4640, DP6640 and DP6440 models embedded thirty (30) inches with a six (6) inch thick footing provide thirty six (36) inches of frost protection. An optional DP Extender can be used with all models to increase the footing depth for frost protection. Table 6.1 shows several options that may be used to achieve the required frost depth specified by the local authority.

TABLE 6.1: FROST PROTECTION OPTIONS						
Option* #	Deck Post Length (in)	Projection Above Grade (in)	Embedment Depth (in)	Footing Thickness (in)	DP Extender Length (in)	Frost Protection Depth (in)
1	30	10	20	4	n/a	24
2	30	6	24	6	n/a	30
3	30	10	20	12	12	32
4	40	10	30	6	n/a	36
5	40	6	34	6	n/a	40
6	40	10	30	12	12	42
7	40	10	30	18	18	48
*Other frost protection option combinations may be used to achieve different frost protection depths						

7. Deck Post Design Chart

Table 7.1 shows the allowable shear, uplift and vertical load capacities of the seven (7) Deck Post models using the materials, design methods and design assumptions described in this manual. The critical component for each of load directions varies between Deck Post models. The foundation system controls vertical and shear capacities of all models and uplift capacity of most models. The underlined values represent uplift capacities controlled by the bending strength of the steel bracket on top of post. All other uplift values are controlled by the uplift capacity of the foundation. Consistent with provisions of the EP486.1 standard, the weight of the concrete column and steel bracket is not added to the uplift resistance of the foundation and may be considered on the load side of the equation. All shear, uplift and gravity values in the table are allowable unfactored capacities.

TABLE 7.1: ALLOWABLE SHEAR, UPLIFT AND GRAVITY LOAD CAPACITIES									
2"x2"x8-1/2" Uplift Angles									
Compacted Soil Backfill									
		10" dia. hole (8" pad)		12" dia. hole (10" pad)		14" dia. hole (12" pad)		16" dia. hole (14" pad)	
Model ID	Shear (lbs)	Uplift (lbs)	Down (lbs)	Uplift (lbs)	Down (lbs)	Uplift (lbs)	Down (lbs)	Uplift (lbs)	Down (lbs)
DP4430	59	299	790	299	1270	299	1880	299	2700
DP4440	165	709	900	709	1450	709	2140	709	3060
DP4640	165	788	900	788	1450	788	2140	788	3060
DP6630	90	279	790	279	1270	279	1880	279	2700
DP6640	260	758	900	758	1450	758	2140	758	3060
DP6430	80	307	790	307	1270	307	1880	307	2700
DP6440	260	772	900	772	1450	772	2140	772	3060
1/2" Rebar x 2" Less Than Hole Diameter									
8" Thick Concrete Collar									
		8" dia hole/footing		10" dia hole/footing		12" dia hole/footing		16" dia hole/footing	
Model ID	Shear (lbs)	Uplift (lbs)	Down (lbs)	Uplift (lbs)	Down (lbs)	Uplift (lbs)	Down (lbs)	Uplift (lbs)	Down (lbs)
DP4430	59	142	790	195	1270	256	1880	409	3630
DP4440	165	423	900	525	1450	639	2140	709	4090
DP4640	165	423	900	525	1450	639	2140	906	3060
DP6630	90	129	790	182	1270	245	1880	396	2700
DP6640	260	399	900	501	1450	615	2140	882	3060
DP6430	80	129	790	182	1270	244	1880	396	2700
DP6440	260	399	900	500	1450	615	2140	772	3060

Chart Assumptions:

1. This chart is for Perma-Column Deck Post models DP4430, DP4440, DP4640, DP6630, DP6640, DP6430 and DP6440 used as a foundation for a wood deck or similar structure.
2. The forces applied from the post or beam to the brackets are a vertical uplift force, a horizontal shear force and a vertical gravity force. Loads shown in the chart are unfactored. Shear force is applied in any direction.
3. The allowable shear and uplift loads in wood have been increased by 60% for wind or seismic loading, reduce where other loads govern.
4. The allowable concrete loads assume a minimum f_c of 2500 psi and 10,000 psi for footings and column, respectively.
5. All rebar in concrete column is #4 weldable A706, Grade 60.
6. Wood to steel connection assumes #17 x 2" Grade 5 galvanized wood screws, quantity as described in this manual, with the wood specific gravity of 0.36 and wet service reductions applied.
7. Uplift angles and concrete collar are attached to post with 1/2" A307 thru bolt and #4 rebar, respectively.
8. Footing is assumed to be 4" thick for agricultural projects and 6" thick for residential and commercial projects. Footings 14" and 16" in diameter are 6" thick for all projects.
9. Footings less than 12" wide are not allowed for residential and commercial projects (*IRC 2009 R403.1.1, IBC 2009 1809.4*) unless the concrete pad is set on 12"(dia) x8" compacted stone base.
10. Grade to top of footing dimension is assumed to be at least 20" and 30" for 30" and 40" models, respectively.
11. The initial allowable vertical soil pressure is 2000 psf. The allowable vertical pressure is increased per Table 1, Footnote 4 of EP486.1.
12. Top of concrete column extends 10" or less above grade.
13. All capacities remain unchanged for columns with an optional DP Extender. The footing thickness shall match the height of the extender and top of concrete column shall not extend more than 10" above grade. Direct bearing between concrete post and footing is required.
14. Column and footing is installed in strict accordance with this manual.

8. DP Extender

All Deck Post models can be fitted with an optional DP Extender. The extender is a $1/8 \times 3 1/2$ " "U" shaped steel bracket that can extend 4" to 24" past the bottom of the concrete column and is attached to the column with (1) $1/2$ " ASTM A307 through bolt. The DP Extender may increase the depth of footing for frost protection. The main benefit, however, is the ability to install a column prior to installing a footing pad, and pour the concrete footing and collar simultaneously in one single pour to create a strong monolithic foundation. Though the vertical, shear and uplift capacities of the foundation are positively affected, the difference is considered insignificant and is not addressed in this manual. When a DP Extender is attached, a design professional may choose to add the weight of concrete below the Deck Post to the uplift resistance side of the equation.

9. AG-CO Molded Plastic FootingPad

All Perma-Column Deck Post models can be installed on AG-CO 10 inch or 16 inch molded plastic FootingPads manufactured by AG-CO Products, Inc., see Figure 9.1. **The internal steel components at the bottom of the Perma-Column Deck Post for this option are different from the standard models and may not be available in some regions.** Specifically, the $1/2$ " PST, described in Section 2 of this manual, is threaded on the inside and placed vertically. The vertical tube extends from the bottom face of the concrete column to vertical rebar where it is welded with $1/4$ " fillet weld all around. The AG-CO molded plastic FootingPad is fastened to the vertical threaded pipe of the Perma-Column Deck Post via one $1/2 \times 1 1/2$ " and $1/2 \times 2 1/2$ " grade 5 bolt for 10" and 16" FootingPad models respectively. The bolt is installed with a 2" diameter x $1/8$ " flat washer on the bottom face of the FootingPad. A more thorough description of this product and installation requirements are provided by ESR-2147 report by ICC-ES and GEE111711-10 report by NTA, Inc.

The uplift capacity for 40" Deck Post models is controlled by the bolt connection between the post and the FootingPad. The uplift capacity for 30" Deck Post models is controlled by the uplift resistance of the foundation. The allowable capacity of the FootingPad to Deck Post connection is calculated as 67% of the least favorable ultimate strength test result found in GEE111711-10 report. The allowable vertical capacity is calculated using provisions of EP486.1, including the increases described in Footnote 4 of Table 1, but does not exceed the maximum vertical capacity described in Table 1 of ESR-2147 report. The calculations of vertical capacity are based on the initial allowable vertical soil pressure of 2000 psf. The allowable vertical and uplift capacities for all Perma-Column Deck Post models with the AG-CO FootingPad option are provided in Table 9.1. The allowable shear capacities remain unchanged from the values provided in Table 7.1. Installation of a concrete collar above the FootingPad is not permitted for reasons described in the Foundation Design Section of this manual. All other requirements and assumptions described in the main text and footnotes of this manual are still applicable unless stated otherwise in this section.

As in the case with concrete footings, the bottom of the molded plastic FootingPad shall be located below the frost depth line as determined by the local authorities.



Figure 9.1: Deck Post on AG-CO Molded Plastic FootingPad

TABLE 9.1: ALLOWABLE UPLIFT AND GRAVITY LOAD CAPACITIES FOR DECK POST ON FOOTING PAD

10" AG-CO Molded Plastic FootingPad Bolted to Base				16" AG-CO Molded Plastic FootingPad Bolted to Base		
Compacted Soil Backfill				Compacted Soil Backfill		
Model ID	Shear (lbs)	Uplift (lbs)	Down (lbs)	Shear (lbs)	Uplift (lbs)	Down (lbs)
DP4430	59	385	1210	59	644	3440
DP4440	165	527	1390	165	841	3900
DP4640	165	527	1390	165	841	3900
DP6630	90	385	1210	90	644	3440
DP6640	260	527	1390	260	841	3900
DP6430	80	385	1210	80	644	3440
DP6440	260	527	1390	260	841	3900

Chart Assumptions

1. This chart is for Perma-Column Deck Post models DP4430, DP4440, DP4640, DP6630, DP6640, DP6430 and DP6440 used as a foundation for a wood deck or similar structure.
2. The forces applied from the post or beam to the brackets are a vertical uplift force, a horizontal shear force and a vertical gravity force. Loads shown in the chart are unfactored. Shear force is applied in any direction.
3. The allowable shear and uplift loads in wood have been increased by 60% for wind or seismic loading, reduce where other loads govern.
4. The allowable concrete loads assume a minimum f_c of 10,000 psi for column.
5. All rebar in concrete column is #4 weldable A706, Grade 60.
6. Wood to steel connection assumes #17 x 2" Grade 5 galvanized wood screws, quantity as described in this manual, with the wood specific gravity of 0.36 and wet service reductions applied.
7. Footing is a 10" and 16" AG-CO Molded Plastic FootingPad by AG-CO Products, Inc.
8. Grade to top of footing dimension is assumed to be at least 20" and 30" for 30" and 40" models, respectively.
9. Top of concrete column extends 10" or less above grade.
10. DP Extender is not permitted with this footing.
11. Deck post has direct bearing on the footing.
12. The initial allowable vertical soil pressure is 2000 psf. The allowable vertical pressure is increased per Table 1, Footnote 4 of EP486.1, but does not exceed maximum vertical capacity described in Table 1 of ESR-2147.
13. Footing is installed in strict accordance with the ESR-2147 report by ICC-ES and GEE111711-10 report by NTA, Inc.

10. Summary and Conclusion

The Perma-Column Deck Post is designed to support wood decks, porches or other similar structures. It can be used as an alternative to cast-in-place concrete piers and embedded wood posts that are incorporated in code-approved prescriptive specifications. This manual provides the allowable gravity, shear and uplift capacities for seven (7) Deck Post models installed with several different foundation sizes and styles. The projection above grade, embedment depth, and footing thickness can be adjusted to accommodate a wide range of frost depth requirements. The Perma-Column Deck Post is a permanent foundation solution for the small structures market.