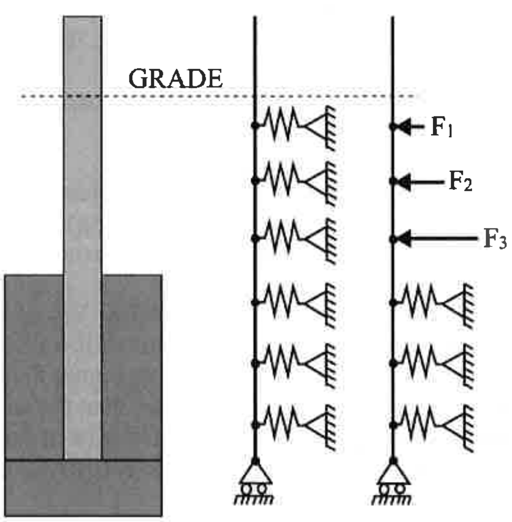
9. Soils: Lateral Assessment

The analysis of the shallow post foundations with the ***Perma-Column*** is the same as one with traditional embedded wood posts. The lateral strength and stability analysis of soils is governed by ASABE EP 486.3. Figures 9.1 and 9.2 show a non-constrained and constrained shallow post foundations, respectively. The non-constrained shallow post foundation is a foundation with no concrete slab or other permanent constraint at grade, while the constrained shallow post foundation does have such a constraint. In most constrained cases, the column/pier is not permanently attached to the concrete slab as is recommended to prevent concrete cracking due to deferential settlement. When the column is pulled away from the building under suction wind loads, the concrete slab is no longer effective, and the foundation is designed as non-constrained shallow post foundation.

EP 486.3 provides two design methods: The Universal Method (EP 486.3, Clause 8.3) and the Simplified Method (EP 486.3, Clause 8.4). The simplified method can only be used if the restrictions outlined in Clause 8.4 are satisfied. Shallow post foundations with concrete collars (concrete backfill) do not satisfy the stipulations of the Simplified Method and are analyzed using the Universal Method. The Universal Method utilizes a series of lateral springs along the length of the column/pier foundation below grade, each representing the load response from the layer of soil in which the spring is located. Each spring is assigned a stiffness value calculated in accordance with EP486.3. If the resulting spring force exceeds the ultimate lateral strength of the respective soil layer, the spring is removed and replaced by a constant force. For the analysis and design of the column/pier, this constant force is equal to the ultimate lateral strength of the soil layer calculated per EP 486.3. At this stage of the analysis, the spring replacement force is not reduced by the factor of safety (ASD) or the design strength reduction factor (LRFD). The ultimate lateral strength represents the upper limit of the elastic behavior of the soil layer beyond which the soil reaction force remains constant even as the soil may continue to deform. It may take several iterations to replace each "failing" spring one by one until all remaining spring forces are equal to or less than the ultimate lateral soil strength at each layer (Figure 9.1). If all springs have been replaced and static equilibrium has not been achieved, the concrete collar (backfill) can be increased in thickens (height) and/or diameter as required.



Iteration 1 Iteration 2, 3..

Figure 9.1: Non-Constrained Foundation

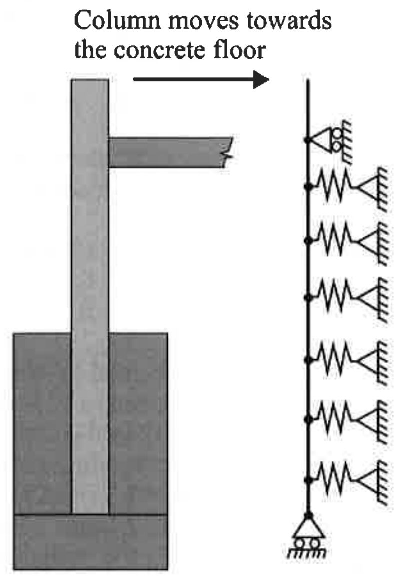


Figure 9.2: Constrained Foundation

The designer should also check the lateral strength of soils, an analysis that requires a separate structural analog (model) one that is similar to the structural analogs in Figures 9.1 and 9.2 except that (1) the structural analog is cut off at grade, (2) the internal shear and bending moment forces from the column/pier analysis, as measured at grade, are applied to the soils structural model as external lateral and moment forces at grade, and (3) each spring that exceeds the allowable (ASD) or design (LRFD) lateral strengths of the respective soil layer is replaced by the allowable lateral soil strength force (ASD) or the design lateral strength force (LRFD). This is different from the model used for the analysis of the column/pier where the replacement force was based on the ultimate soils strength. The allowable lateral soil strength (ASD) and the design lateral soil strength (LRFD) are determined by dividing the ultimate lateral soil strength by the factor of safety (ASD) or multiplying the ultimate lateral soil strength by the strength reduction factor (LRFD), respectively. The analysis based on the lateral soil strength may result in concrete collar (backfill) that is larger than what was required for the analysis of the column/pier.

10. Soils: Bearing Assessment

The bearing strength of shallow post foundations is governed by ASABE EP 486.3 Chapter 10 and includes allowable strength design (ASD) and load and resistance factor design (LRFD) methodologies. EP 486.3 includes provisions for different soil types and consistencies and includes prescriptive design values and values obtained through different testing methods. Some building officials, however, will not accept EP 486.3 soil bearing values and will provide values they deem acceptable for the location of the project and allow no increases with depth or width of the footing. Foundation designer should verify acceptable bearing pressures with the local authorities.

11. Soils: Uplift Assessment

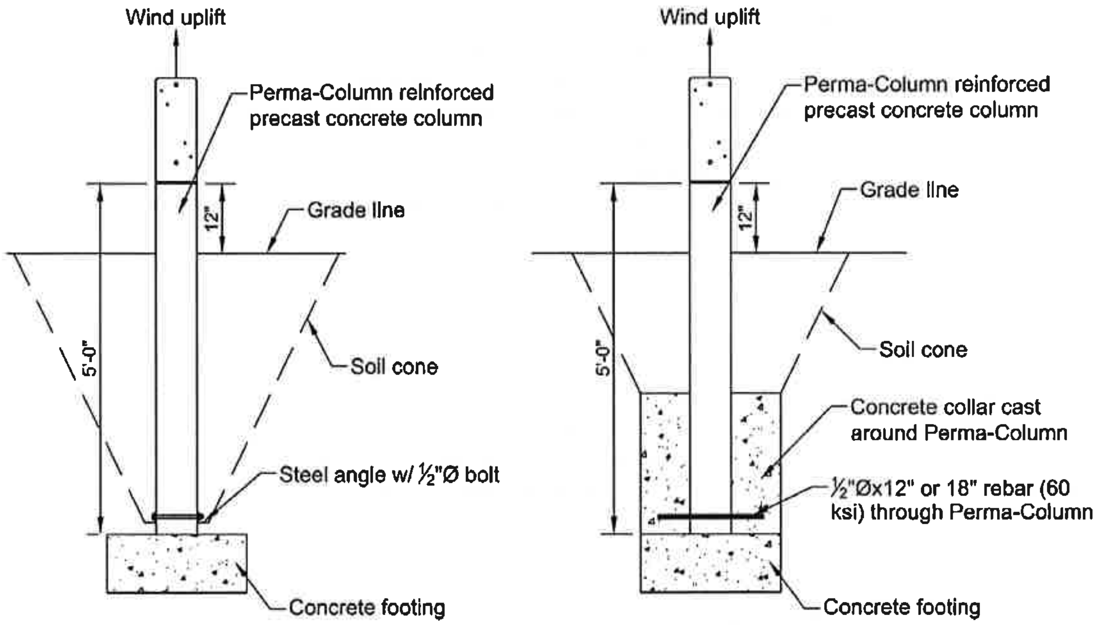
The uplift strength of shallow post foundations is governed by ASABE EP 486.3 Chapter 12. The uplift resistance is achieved via the weight of the concrete mass around the column/pier (concrete collar if present and concrete footer if attached to ***Perma-Column*** via the PC Extender) and the weight of the displaced soil cone. Per EP 486.3, the weight of the soil cone is divided by the factor of safety (ASD) or multiplied by the uplift strength reduction factor (LRFD) while the weight of the attached concrete mass is not reduced. The uplift resistance provided by the displaced soil cone is defined in Section 12.5 and includes provisions for different soil types and conditions and round and square or rectangular uplift devices (round concrete collar, steel uplift angles).

Figures 11.1 and 11.2 show three foundation conditions that may be used with a ***Perma-Column***: (1) steel uplift angles, (2) concrete collar and (3) PC Extender. The allowable uplift strength (ASD) and the design uplift strength (LRFD) of the foundation should be taken as the lesser of two, the uplift strength of the concrete mass and the soil cone calculated per EP 486.3 or the uplift strength of the Perma-Column assembly as defined in Table 11.1.

Table 11.1: Tensile Strength of *Perma-Column* Assembly (lb)

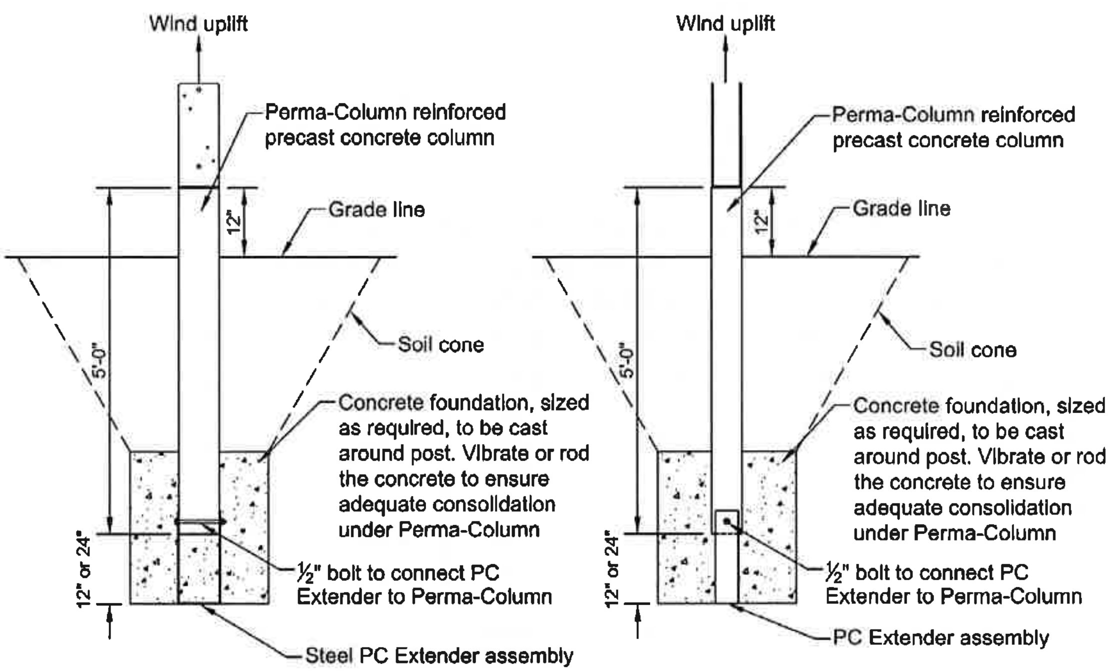
	Steel Angles with ½" A307 Bolt		Concrete Collar with #4 60 ksi Rebar		PC Extender ½" A307 Bolt		PC Extender ½" A325 Bolt	
Series	**(ASD) T_a**	**(LRFD) φT_n**	**(ASD) T_a**	**(LRFD) φT_n**	**(ASD) T_a**	**(LRFD) φT_n**	**(ASD) T_a**	**(LRFD) φT_n**
PC6300	1,410	2,120	*6,050*	*8,160*	4,800	*8,160*	*6,050*	*8,160*
PC6400	1,410	2,120	6,030	*8,160*	4,800	*8,160*	6,030	*8,160*
PC6600	1,410	2,120	*6,050*	*8,160*	4,800	*8,160*	*6,050*	*8,160*
PC8300	1,410	2,120	*8,480*	*11,440*	4,800	8,640	*8,480*	*11,440*
PC8400	1,410	2,120	*8,480*	*11,440*	4,800	8,640	*8,480*	*11,440*
PC8500	1,410	2,120	8,210	*11,440*	4,800	8,640	8,210	*11,440*

1. Values for the Steel Angles are governed by the bending strength of the angles.
2. Values for the Concrete Collar and PC Extender presented with regular font are governed by the shear strength of the fastener (bolt/rebar) at the bottom of the ***Perma-Column***.
3. Italicized values are governed by the lateral strength of the fasteners attaching the steel U-bracket to wood column (SP)
4. Underlined values are governed by the bending strength of the steel U-bracket (bending due to tensile load)



Standard Design Concrete Collar

Figure 11.1: Standard Foundation and Foundation with Concrete Collar



PC Extender View 1 PC Extender View 2

Figure 11.2: Foundation with PC Extender