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**PRO-footer® Post Frame Foundation System**  
**Analysis of Up-Lift Plates**

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Analysis is for wood posts with UP-Lift Plates™ located on opposite sides of the posts near the bottom. The bottom section of the posts with the UP-Lift Plates™ are encased in concrete foundations.



### Description

Uplift Plates™ By PRO-footer® are an adaptation of wood connector plate technology designed to meet or exceed post uplift requirements. These plates are field applied with a framing hammer. The plates are fabricated from 3" wide by 7" (minimum) long MiTek® Model M18SHS™. The plates are ASTM A 653 SS G60 hot dipped galvanized 18 gage grade 80 steel, having 3/8" long teeth, punched in pairs formed at right angles to the face of the parent metal so that two teeth per hole occur along the length. There are eight teeth per square inch to attach the plates to the posts. An uplift restraining angle is bent into the plate at the 3½" center section having no teeth. When the post bottom with the plates is encased in the concrete footing, the concrete in compression above the angle provides the uplift resistance.

### Overview

In order to establish the wind uplift capacity of the post foundation system, the analysis shall take into account factors having to do with the wood, concrete, and metal that may control the design. The metal-plate-connected wood-to-concrete joint can fail in any of 6 modes: steel shear, steel tension, tooth withdrawal, concrete shear, concrete tension, and net section of the wood at the joint. Existing mechanical tests were researched and new tests were completed to define the governing initial mode of failure and the resultant load. A safety factor shall be applied to the load for the purposes of structural designs using the Uplift Plates™. The safety factor shall be determined as required by International Building Codes for similar metal-plate-connected wood-to-concrete joints, based on recommendations by the American Society of Timber Construction and the National Forest Products Association's "National Design Specification for Wood Construction", and the Truss Plate Institute's "Design Specifications for Light Metal Plate Connected Wood Trusses".



The observed mode of failure for the metal-plate-connected wood-to-concrete joint with is tooth withdrawal.



The plate tooth bending, withdrawal, and slippage of the wood was revealed after the tests by impact splitting of the concrete mass to remove it from the post.





### Analysis

It is anticipated that the working stress uplift capacity of the Uplift Plates™ shall exceed the resisting dead load of the largest practical concrete-mass post footings. Because of the various wood posts and concrete mixes that are utilized, tests of the ultimate capacity of Uplift Plates™ require that these components are strong enough to permit the failure to occur at the metal plate joint. The tests were therefore performed on assemblies consisting of a nominal 3-ply 2x6 #2 SYP post with 2 – 3” x 7” (minimum) M18SHS plates, encased in 3 cubic feet of 3,000 psi concrete.

The objective of the tests was to determine the behavior of the metal-plate-connected wood-to-concrete joint assembly under axial tension parallel to the grain of the wood posts. The posts were loaded in tension and the concrete mass was restrained. The results of the tests indicated the mode of failure to be slippage of the plates, and reported the ultimate tensile loads at slippage to be in excess of 30,000 pounds.

The failure commences at the loss of controlled gripping of the wood post specimens by the teeth of the M18SHS plates. The rationality of the induced failure of the Uplift Plates™ is not dependent on the concrete strength or the size of the post.

MiTek® Model M18SHS™ plates have been tested by the International Code Council’s Evaluation Service and the allowable design values are reported in Table 2 of ESR-1988 ANSI Product Certification, last revised April 2011. The similar results of the Uplift Plate™ tests prove the existing MiTek® data is applicable.

From Table 2 of ESR-1988 ANSI Product Certification, last revised April 2011 –

For the case with tension at 90° and the maximum net section at joint,

1. Allowable effective tension = 1,975 lbs/” / pair of plates
2. Inches of teeth on the modified M18SHS = 4.5”
3. Allowable tension on the wood-to-concrete joint = 4.5” x 1,975 lbs/” = 8,888 lbs

Tooth withdrawal safety factors –

1. For the development of working stresses for connection of structural members utilizing metal plate connections, the tooth withdrawal design values are based on tests with five replicate specimens (25) loaded in tension

2. The design load is determined by taking the minimum of the following:
  - 1) the sample average ultimate load divided by 3.0; or
  - 2) the average load at critical slip (0.030 in.) divided by 1.6.
3. When the ultimate test load average divided by 3.0 limits the allowable design value for a specific plate type, the test average tooth withdrawal strength is 3.0 times the published allowable design value for the plate. This procedure for determining tooth withdrawal design values implies that the published design values contain a safety factor of 3.0 based on the average 10-minute test strength.
4. Alternately, the Truss Plate Institute defines a safety factor with respect to the fifth percentile of the tooth withdrawal strength distribution. Using the fifth percentile of the distribution (and consequently a smaller safety factor) is permissible, however, engineers and building code officials are accustomed to larger factors of safety for connections based on the average test strength. Regardless of the safety factor analysis approach used, the net result is that the average 10-minute test strength is equal to 3.0 times the published design values for the plate.

From the Physical Tests –

Reported ultimate tensile loads at slippage = 30,000 lbs

1. Working stress as defined by building code employs a factor of safety based on the ultimate stress,
2. The safety factor shall consider –
  - a. The influence of imperfections on mechanical properties of structural members
  - b. The strength properties of different species or grades in various structural sizes
  - c. The effects of chemical or environmental conditions on mechanical properties
3. Use a safety factor of 3.0 to factor the ultimate load experiencing tooth withdrawal failure mode
4. Expected working stress load,  $30,000 \text{ lbs} / 3.0 = 10,000 \text{ lbs}$
5.  $10,000 \text{ lbs} > 8,888 \text{ lbs}$ , the expected working stress load exceeds the allowable design load
6. Should wood and concrete of smaller sizes or lesser material strengths than those tested, be connected by the UP-Lift Plates™, it is understood that working stress capacities of these components may be less than the capacity of the UP-Lift Plates™.

### Design Capacity

Use 8,888 lbs for the allowable design uplift capacity for wood posts with UP-Lift Plates™

Find the equivalent footing size corresponding to the uplift resistance provided by the connection:

$$8,888 \text{ lbs} / 150 \text{ lbs/ft}^3 = 59.25 \text{ ft}^3$$

Equivalent footing concrete mass –

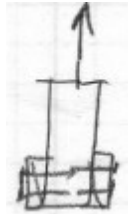
4' 8" diameter x 42" deep, or  
4' 0" diameter x 60" deep

The connection with UP-Lift Plates™ exceeds the anchoring capabilities of the largest practical concrete-mass post footings.



Compare with capacities of alternative details:

uplift block with nails



2x6 block on both sides of post

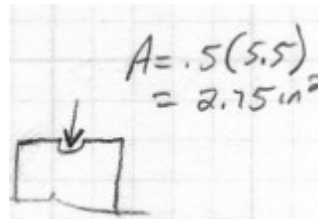
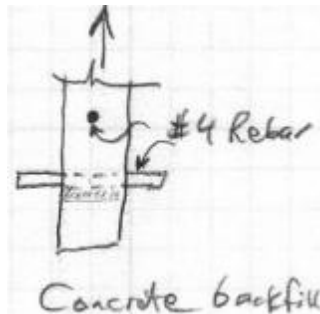
(6) 20d galvanized nails per block (each side)

Nail capacity in shear,  $z' = z C_D C_M = 152 \text{ lbs } (1.6)(0.7) = 170 \text{ lbs}$

Uplift force = (12 nails)(170 lbs) = 2,040 lbs  $\ll$  8,888 lbs

Uplift Plates™ are significantly better.

Rebar through post



1/2" diameter (#4 rebar)

Check wood crushing

$F_c' = F_c C_M = 525 \text{ psi}$

Uplift force = (2 rebars)(525 psi)(2.75 in<sup>2</sup>) = 2,888 lbs  $\ll$  8,888 lbs

Uplift Plates™ are significantly better.



### Conclusion

The analysis shows that the maximum uplift capacity for PRO-footer® Post Frame Foundation System with Uplift Plates™ is 8,888 lbs, and is controlled by bending, withdrawal, and slippage of the plate teeth. Use of this system ensures bond strength between posts and foundation concrete significantly in excess of the capacities of other components.