TOTAL POST-FRAME BUILDING DESIGN

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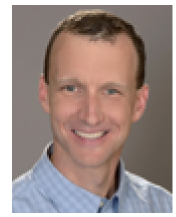

"Things should be made as simple as possible, but not simpler." - Albert Einstein

Analyzing and deciding how to make things as simple as possible can be complex. In Post-Frame construction, consider project requirements such as: choosing the right building products and specifications; building codes and permits; material and labor as they affect total installed cost; establishing building design loads (strength); and quality control in a chaotic and fast-moving environment.

Post-frame construction dates to the 1930s yet is still not well understood in many applications where it could be the ideal candidate for new construction. As an introduction to the uninitiate and as an introduction to more advanced topics for designers and engineers, I present three distinctive features of post-frame construction in this article, what benefits they offer and what challenges must be faced in these three areas so that this economical construction method is not over-simplified in the process of trying to keep things as simple as possible.

How is Post-Frame Construction Different?

Post-frame construction is characterized by structural posts acting as vertical columns spaced at least 4 feet apart. The posts provide the primary framing for the walls which support the roof system which often (but not always) consists of Metal Plate Connected (MPC) trusses. The posts transfer the vertical loads (such as snow, dead, and occupancy/live loads) from the roof and interior floor systems to the foundation, while also assisting in resisting horizontal loads (from wind, seismic, and/or bulk storage sources).

Post-frame columns typically consist of dimensional lumber material that is assembled into a larger member (per ASABE / ANSI EP559.1) with fasteners (usually nails, sometimes screws, possibly bolts or other methods). Alternatively, dimensional lumber is often glued together in a quality-controlled manufacturing setting with the resulting columns identified as a GluLams. Other options exist, including solid sawn posts (such as 6x6 or 8x8), structural steel members (HSS or W-shapes), precast concrete columns or other innovative materials.

Feature 1—Embedded Posts

The first distinctive feature of post-frame construction is that vertical posts or columns are often embedded in the ground. Vertical structural elements which are continuous in their load carrying capacity from the footing up to the roof system offers economical and effective distribution of building loads down into the foundation. See cutaway view of a Post-Frame portion in *Figure 1*.

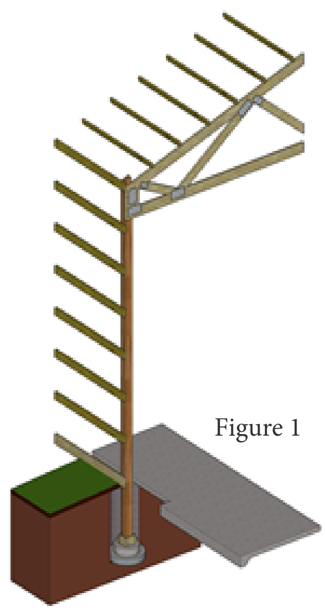

Figure 1 – Cutaway view of a partial post-frame building (*Source: Halberg Engineering*)

Embedding the vertical columns into the soil is a common practice that is well-suited to post-frame buildings and offers many benefits, including: lower lateral forces transmitted into the roof and wall diaphragm systems, less excavation / site work, less cast-in-place (CIP) concrete required in the foundation (sometimes eliminating all CIP), more flexibility in construction sequence, and improved speed of construction.

Some challenges or keys to successfully embedding columns include proper preservative-treatment for wood in the embedded region (extending from the base to at least 16" above finished grade), using a properly sized footing to resist the bearing forces, establishing a reliable method to resist uplift forces, and performing proper backfilling procedures around the embedded posts once it is in position. Structural analysis may be challenging for designers to resist the combination of horizontal, vertical, and uplift loads on a particular design. These capabilities vary depending on soil conditions at the site, geometry of the building, size of the post being used and the magnitude of loads that each post within the building must resist. See ***Figures 2 and 3 and Photo 1*** for illustration of bearing and uplift forces transmitted into the foundation.

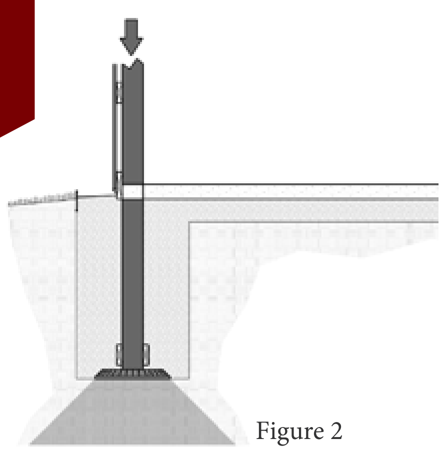

Figure 2

Photo 1

Figure 2 – Embedded column showing vertical forces transmitted to footing and soil (Source: AG-CO Products / Halberg Engineering)

Photo 1 - Photo Credit - FootingPad by AG-CO.

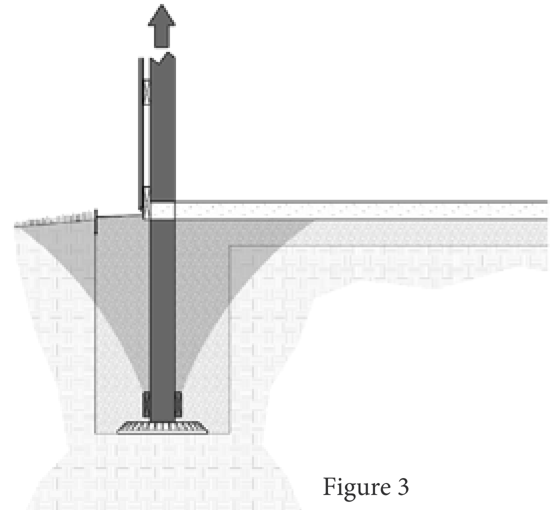

Figure 3

Figure 3 – Embedded column showing uplift forces resisted by soil above uplift blocks. (Source: AG-CO Products / Halberg Engineering)

Indispensable information regarding the proper use of embedded columns can be found in the Post Frame Building Design Manual available from NFBA (nfba.org) and the Engineering Practice published by the American Society of Agricultural and Biological Engineers (available at elibrary.asabe.org): EP486 Shallow Post and Pier Foundation Design.

Feature 2—Trusses Used at Intervals Greater Than 2 Feet

Although what is considered "typical" varies by region, post-frame trusses are usually spaced at least 4 feet on center. In direct bearing roof systems, truss spacing will match the normal post spacing and is usually at least 6 feet and often 8 feet, or even 10 to 12 feet in certain applications.

The flexibility in truss spacing and spanning large areas has been made possible by the advancement in design and manufacturing of metal plate connected wood trusses over the last several decades. The roof trusses should be one of the first structural components designed for a post-frame project to confirm the desired roof geometry is possible. This roof design is then supported by necessary columns, beams, and other structural elements, including the connections to make sure the structural load path is continuous and reliable.

Truss designers and manufacturers have an efficient system of generating Truss Design Drawings (TDD) to confirm that the desired solution can be served by intended MPC trusses along with an estimate of the cost. Once the acceptability of the design is confirmed by the building designer and/or the builder and owner, the TDDs will be reviewed by the manufacturer's engineer and certified with an engineering seal, but this certification ONLY relates to the truss to resist the requested loads and assumes the MPC trusses will be installed and braced properly. Also, that they will be installed as part of a complete building system which is properly designed, braced, and constructed to support the trusses. The truss designer who certifies the truss design will explicitly NOT take any responsibility for the building design.

Some owners, and maybe even some builders, may see the engineer's certification on the TDD and conclude that this is now a complete engineered building system, but an engineered truss component does not make an engineered building and should never be represented as such. Total post-frame building design requires all structural members to be designed, not just the roof trusses.

Benefits of using trusses at spacing greater than 2 feet is a significant reduction in the total amount of material required and the time to erect the building. Also, the increased spans between trusses require purlins to support the roof cladding and these purlins running perpendicular to the trusses serve as the ideal supporting system for through-fastened steel roofing panels, which is common for post-frame construction. The system of secondary framing perpendicular to the primary framing is suitable for cladding attachment on the roof and for the walls by framing secondary girt members to the primary column members.

Challenges using trusses at larger spacing include the importance of confirming that truss design assumptions reflect the intended building to be constructed. Also, truss bracing requirements and connections to the building must be designed by the qualified BUILDING designer (although many people incorrectly believe the TRUSS designer takes care of bracing and truss connections before sealing the TDDs). The Building Component Safety Information (BCSI) guidelines include one topic intended specifically for trusses used in post-frame buildings, "B10–Post Frame Truss Installation & Temporary Restraint/Bracing." Only by properly installing these engineered trusses into a well-designed building system and connecting them properly can it be ensured they will support the loads for which they were designed.

Suggested resources for additional information about properly using trusses in post-frame buildings include the previously mentioned PFBDM and two publications by the Truss Plate Institute (TPI). *ANSI/TPI 1: National Design Standard for Metal Plate Connected Wood Truss Construction. Also: TPI/SBCA Building Component Safety Information (BCSI).*

Feature 3—Metal-Clad Wood-Frame Diaphragms

Metal-clad, wood-framed diaphragms are created when light-gauge, roll-formed steel or aluminum panels are fastened with nails or screws to the wood framing (purlins in the roof and girts in the walls) and are historically the most common exterior material utilized in post-frame buildings but are certainly not required. Studying and documenting the strength and stiffness characteristics of MCWF diaphragms was one of the major areas of research efforts in the second half of the last century as post-frame construction moved from its agricultural origins into commercial and residential applications.

The steel panels used in post-frame buildings are often used in lighter gauges (thinner base metal thicknesses, such as 26, 28 or 29) than other types of construction. But because of the large area of these panels in the roof and walls, these thin steel panels fastened to the framing in a repetitive and regular manner creates a structural system capable of resisting significant in-plane forces.

Chapter 6 in the *PFBDM* is devoted to Diaphragm Design and Chapter 7 to Metal-Clad Wood-Frame Diaphragm Properties. Also, two additional ASABE Engineering Practice documents will be helpful for the designer looking for technical information on the topic: *EP484.2 Diaphragm Design of Metal-Clad, Wood-Frame Rectangular Buildings*, which is adopted in the International Building Code, and *EP558.1 Load Tests for Metal-Clad Wood-Frame Diaphragms.*

Interdependence

Understanding these three distinctive features of post frame should help you distinguish it from other building systems and—more importantly—make you keenly aware of the importance of having the entire building system designed to form an integral building system.

Post-frame buildings are so efficient because they are highly interdependent structures in which the individual systems function together to become more than the sum of the parts. Think of the embedded posts being laterally supported by an MCWF diaphragm in the roof, supported by properly braced long-span trusses, a design that transmits loads into the walls of the building and down through the MCWF shearwalls of the building and into the foundation (again, this could be an embedded post load path). The benefit of the building system efficiency comes at the cost of understanding and taking care of these interdependent relationships throughout the process of conceiving, designing, procuring, constructing, and maintaining these buildings, but I believe this care is well worth the cost—for each individual building and for the entire post-frame industry.

Because of the interdependent nature of the post-frame features, especially when the sizes get large or whenever embedded columns are utilized, it has proven difficult to create a prescriptive post-frame design solution that is adequately flexible and usable without being overly conservative. Maybe that day is coming, but the ideal post-frame prescriptive requirements would need to balance at least three factors: be as simple as possible (Einstein again!), structural reliability (safety) and an efficient, cost-effective result (economical).

These three factors are not easily resolved to the point where everyone would be satisfied with the results for their building situations, which leads to the current situation where post-frame builders may benefit from hiring a structural engineer directly or establish a relationship with an engineer that does such work as a consultant. Consider the "Find a Provider" feature at the NFBA website (nfba.org) and choose from Supplier, Builder, and Designer when choosing what to look for.

Alternatively, for post-frame projects that "wing it" with a designed roof truss (only) and some rules of thumb for the building based on other structures which have not collapsed (yet), you really cannot predict the reliability of such a building when it faces high winds, heavy snows or ice, earthquake loads, its own weight, or the combination of two or more of these loads at the same time. Hence, I believe a total building design approach is more important for post-frame construction than most people currently appreciate.

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