12 structural applications for post-frame

Understanding these is key to market expansion

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Any salesperson looking to expand their market must first identify potential markets. Identifying potential markets begins, in turn, by identifying the unique characteristics of the product being marketed. Once a product's unique characteristics have been identified, markets that will benefit from the characteristics can be defined.

Application of this process to post-frame buildings means that the unique characteristic(s) of the post-frame building system must be defined, and then post-frame building markets identified. Although this may seem obvious, it appears to me that as a building organization, we have not clearly defined the unique characteristic or characteristics of the post-frame building system, nor have we identified all potential market opportunities.

It's just a structural framing system

Prior to identifying the unique characteristic(s) of the post-frame building system, one thing needs to be clearly understood: It's just a structural framing system.

This means that a post-frame building system is NOT an interior or exterior wall finish system, nor is it a roof, ceiling, or floor finish system, nor is it a thermal insulation system, nor is it any other type of building system that you can think of. It is also extremely important to realize that when you select a post-frame building system as your structural framing/support system, you are NOT locking yourself into any specific wall, roof, ceiling or floor finish, nor are you committed to any particular thermal insulation system.

While it is clear to most post-frame builders and designers that "a post-frame building system is just a structural framing system," it evidently is not very clear to a number of individuals sitting on zoning boards across the country. If it were clear to these individuals, they would not partake in the utterly ludicrous practice of zoning out a particular framing/support system when their real desire is to control some other building characteristic/system. Nevertheless, when a zoning board votes to disallow post-frame buildings within a particular area, this is exactly what they are doing.

The problems posed to the post-frame building industry by zoning boards occurs in large part because zoning boards associate the "post-frame" framing system with less expensive exterior finishes – finishes that they feel will negatively impact surrounding home values. The mindset that framing systems dictate finish systems needs to be altered.

To this end, there is a need to demonstrate that a post-frame building system, like any other major framing system, can support virtually any exterior finish system. In a nutshell, many existing, architecturally-stunning, non-post-frame buildings could have easily, and in many cases more efficiently, been framed using a "post-frame" framing system.

To promote the fact that "a post-frame building system is just a structural framing system," it often helps to overview other structural framing/support systems. In general, a structural framing/support system is either concrete-based, steel-based, wood-based or a combination of these three.

Concrete-based systems include buildings supported by either masonry walls, precast concrete components or steel-reinforced, cast-in-place concrete components.

Steel-based systems range from the high-rise, three-dimensional steel-framed structures to buildings entirely framed with cold-formed, light-guage steel components. In between these two steel-framed assemblies are low-rise metal building systems, which are more commonly referred to as pre-engineered steel buildings (even through all buildings of note are pre-engineered).

Wood-based framing/support systems include log, timber-frame, light-wood frame, structural insulated panel (SIP), and of course, post-frame.

Selection of an appropriate structural framing/support system is one of the first steps in building design. When selecting a framing/support system, the building designer is looking for some particular balance of the following seven desirable building traits or characteristics: **F**unctionality, **A**ffordability, **C**omfort, **A**esthetics, **D**urability, **E**nvironmental-friendliness and **S**afety. Note that after I developed this list, I found that the first letters of these seven traits spell the word **FACADES.**

Uniqueness of the post-frame building system

A significantly greater market share for post-frame will be achieved primarily by exploiting structural framing advantages that the system has over other framing/support systems. This, in turn, requires that the unique structural characteristic(s) of the post-frame building system first be identified.

From time-to-time over the past quarter century, I have addressed the question "What makes post-frame buildings uniquely different from other framing systems?" Last October, during a meeting of the NFBA Technical and Research (T&R) Committee in Utica, IL, I again found myself addressing this question. It came during a mid-morning discussion led by Dr. Harvey Manbeck on his latest draft of a "Model Specification for Post Frame Building Systems."

As the focus of the draft specification turned to its overall organization, it became apparent we needed to identify those characteristics of a post-frame building system that make it a unique framing system; this since location of such core characteristics need to be located in the beginning of the document to ensure they are the first building items specified during actual document use.

As the discussion wore on, two things came clear from an academic design professional's perspective.

First, wood posts are the main vertical framing element in ***all*** post-frame buildings. Without wood posts, there is no post-frame building.

Second, there is no ***roof*** framing system that is unique to post-frame. Any roof framing system used in post-frame could be (and likely has been) placed on a light-wood frame wall (a.k.a., wood stud wall), a log wall, a SIP wall, a masonry wall, a light-gage steel-stud wall, etc.

This fact became apparent when it was agreed that "a building featuring 24-inch on-center trusses/rafters attached to post-supported headers," is a post-frame building just as much as a building in which all trusses or rafters are attached directly to posts. That said, it should be noted the roof of a post-frame building is framed using nominal 2-inch thick lumber or similar-sized engineered lumber components. This makes it different from timber-framed and post-and-beam systems in which larger glulams and solid-sawn timbers are used as primary roof framing members.

The discussion at the NFBA T&R Committee led me to draft the following simple, yet rather effective, definition for a *post-frame building system*.

Here's the definition; it's just this simple

The term "post-frame building system" refers to any structural framing/support system whose main, load-bearing, vertical framing elements are wood posts. These posts may be embedded in ground, supported by concrete piers, or attached to a concrete wall or slab. They support trusses, rafters and/or headers made from nominal 2-inch thick lumber or similarly-sized engineered lumber products. They are often laterally supported by horizontal members called girts whose spacing can be varied to accommodate applied loads and sheathing needs. Post size and post spacing are dictated by such factors as: size of wall openings, wall heights, spacing of primary roof framing, and type and magnitude of structural loads.

In most post-frame buildings, almost every truss (or rafter) is directly attached to one or more wood posts. When a single truss is attached directly to posts, a large two-dimensional *post-frame* is formed. The connection of a series of

Figure 1. The numerous, equally-spaced overhead doors of min-warehouses make them ideal for post-frame.

Figure 2. Large, equally spaced windows suit post-frame.

Figure 3. Post-frame easily accommodates the size and relative location of door and window openings in this building.

post-frames with girts and purlins produces the structural skeleton of what many people visualize, and would even define, as a more "pure" or "true" form of the post-frame building system.

I would recommend that, as an industry, we refer to any post-frame building in which virtually all trusses (or rafters) are attached directly to wood posts as a ***classical*** *post-frame building system*.

Note that it is this classical framing system that is the mirror structural image of the framing system used in low-rise steel frame (a.k.a. pre-engineered steel) buildings; in fact, the two framing systems use the same nomenclature. Both framing systems have large 2-dimensional *primary frames*, connected with *secondary framing* members called *girts* and *purlins*.

As an aside, I would point out that the low-rise steel frame building industry refers to any sidewall member that simultaneously functions as both a wall girt and purlin as an *eave strut*. The use of the word "strut" recognizes (1) the importance of the member in handling and transferring axial forces, and (2) that bending stresses induced in such members are significantly lower than in regular girts and purlins. I have used the term "eave strut" in some of my writings when referring to a sidewall girt to which both roof and wall sheathing are attached in post-frame buildings, and I would recommend broader adoption of the term by our industry.

12 structural applications ideal for post-frame

Expansion of the post-frame building market will occur when building designers more frequently select the post-frame building system over other structural framing/support systems. In my opinion, this will only occur when they become familiar with all the applications in which the post-frame building system has inherent structural advantages that make it the most cost-effective framing/support option. Based on the previous definition of post-frame, this includes those building applications where it is advantageous to have wood posts as main, load-bearing, vertical framing elements.

Following are 12 such applications.

Application 1: Buildings with numerous and/or relatively large wall openings. Windows and doors in a post-frame building that are narrower than the post spacing typically do not require structural headers, since roof trusses/rafters in most post-frame buildings bear directly on the posts. Elimination of structural headers enables elimination of trimmer studs (a.k.a. jack studs, shoulder studs) and other special structural members required to support the headers.

Removing headers and their supports not only saves money, but results in an enhanced thermal envelope when framing members are replaced with thermal insulation. Additionally, fewer framing members means fewer cracks for air infiltration.

Mini-warehouses (figure 14) and service garages typically have several equally-spaced and equally-sized overhead doors making them ideal candidates for post-frame. In these buildings, posts are often used to frame both sides of the doors.

Replace the doors in a mini-warehouse with large glass panels, and you can understand why post-frame is also ideal for retail stores with large glass facades (figure 2). In general, any

Figure 5 (above). Splice region of a glue-laminated post in which preservative-treated lumber has been finger-jointed to non-treated lumber.

Figure 4. Mechanically-laminated post attached to a precast concrete pier.

Figure 6. The ability to construct inexpensive buildings with relatively high eave heights makes post-frame ideal for many machinery storage buildings including this airplane hangar.

building with large, regularly-spaced door and window openings is an ideal candidate for post-frame (figure 3).

Application 2: Buildings without basements. Many buildings without basements are supported on cast-in-place crawlspace walls or frost walls that rest on continuous cast-in-place concrete footings. The construction time and concrete cost associated with these continuous concrete foundation walls and footings is significantly greater than that associated with a post-frame building that utilizes embedded posts or a post-on-concrete pier system (figure 4) as its foundation system.

The material and labor savings associated with post/pier foundation systems makes them the most environmentally-friendly foundation system in common use today. Additionally, embedded post and precast pier foundations can be easily removed and reused — a feature that adds to their status as a very environmentally-friendly foundation system.

Most buildings without basements feature concrete slab-on-grade floors. More frequently today, these slabs contain radiant heating systems. When post/pier foundation systems are used, the interior concrete slab can be placed after the building shell has been erected. This has two major advantages.

First, concrete is much more protected during its placement from wind, precipitation in all forms, and temperature extremes. This can translate into fewer unexpected scheduling delays, less need for costly heat and moisture protection systems, and enhanced concrete surface finish, durability, and strength properties.

Second, less preplanning is required for below slab installation of HVAC, plumbing and electrical system components. In fact, no preplanning is required when the interior concrete slab is placed after HVAC, plumbing and electrical system installations have been completed. With respect to utilities, it is also important to realize that insulation must be placed under a slab that contains a radiant heating system, and placement of this insulation requires a very level, properly compacted base — something more easily achieved and maintained in a protected environment.

Some builders may opt to place posts on the thickened edge (i.e., grade beam) of a concrete slab. Such systems generally require more total concrete than systems with concrete pier foundations since the extra concrete required for the grade beams usually exceeds that required to fabricate the concrete piers. Additionally, the probability of a foundation failure is greater for floating slab foundations than for buildings completely supported on piers and other foundation systems that extend below the frost line.

Application 3: Buildings with tall exterior walls. Mechanically- and glue-laminated posts (figures 4 and 5, respectively) are used in the vast majority of today's post-frame buildings. These posts enable the construction of buildings with relative large floor-to-ceiling heights at prices much less than they could be fabricated with a comparable wood stud wall.

Laminated posts can be fabricated to any length by splicing shorter pieces of wood together. Laminated posts are also straight and inherently more stable because of the laminating process. The only way to get a tall, relatively straight wall with

Figure 7. This building is typical of dairy freestall barns. The greater width of these buildings results in tall gable endwalls requiring substantial framing, and need for interior support posts.

Figure 8. High wall pressures and resistance of wood to corrosion make post-frame the perfect application for salt storage facilities.

Figure 10. The desire for open sidewalls makes the post-frame building system a popular choice for park and other recreational shelters.

Figure 11. Post-supported floors and mezzanines and provide for more open floor plans.

Figure 12. Truss resting on outer ply of a laminated post. Steel L-bracket placed on outer face of truss to help reinforce post-to-truss connection.

Figure 13. When truss is sandwiched between outer plies of a mechanically-laminated post, bolts are placed in double-shear for a very effective connection.

wood studs is to use more expensive, engineered lumber products (e.g., laminated strand lumber, parallel strand lumber).

As wall height increases, bending moments in the wall's vertical framing elements increase. This increase is not minor. Bending moments induced by uniformly-applied loads increase with the square of the unsupported length of a member. This means that a 20-foot wall stud is subjected to a bending moment that is four times greater than that for a 10-foot wall stud with the same on-center spacing.

Laminated posts are able to deal with increases in bending moment more effectively than solid-sawn posts. This is because weak areas in one layer of a laminated assembly are supported by adjacent layers — layers with a low probability of having a weakness at the same location. This support of weak areas in one layer by the adjacent layers gives rise to the phenomena of load sharing. Load sharing is very important in any area of a laminated assembly in which there is a butt joint between two members. Because of load sharing, the design strength of a laminated assembly is greater than the summed total of its individual layers prior to lamination.

The increased bending moments associated with taller walls may be handled by using higher grade lumber or with larger vertical wall framing elements. Another option is to reduce the spacing of the framing elements so that each element is subjected to less load. These options are easy to accommodate into post-frame building design. It's one more reason why they get the nod over other framing systems in tall wall applications.

The cost advantage that post-frame buildings hold over low-rise steel frame buildings generally starts to disappear once minimum floor-to-ceiling heights move beyond 20 feet. Below these heights, post-frame holds thermal insulation advantages, if not cost advantages, over steel frame structures. This has made post-frame very popular for storage facilities such as the airplane hangar in figure 6.

It is not uncommon for the required length of vertical wall framing elements to be significantly different in various locations within a building. Where such length variations occur, structural requirements for the longer elements generally control framing/support system selection. Significant wall framing length variations most commonly occur in the endwall framing of wide buildings with sloped ceilings (the dairy freestall barn in figure 7 is one such example). Not surprisingly, the endwalls in many of these buildings are post-frame.

Application 4: Bulk storage buildings. Bulk storage refers to storage of a relatively large quantity of a particular material or commodity such as cement, sand, salt, fertilizer, fruit, a vegetable, seed, feed, cotton, straw, aggregate, etc. If a bulk storage building wall is used to contain stored material, that wall must be designed to resist the resulting horizontal pressure which is directly dependent on the height of the stored material. Even for stored material heights of only a few feet, this pressure will be several times greater than the pressure applied to exterior walls by even the highest of winds.

As noted in the previous section, higher wall forces are easily accommodated in post-frame building design by altering post size and/or spacing. Post spacing is generally dictated by the spanning capability of the structural material used to contain

Figure 14. Non-structural straw bale walls prior to plastering.

Figure 16. Clay-coated straw walls after removal of the slip forms used to pack the wet clay-coated straw into place between and on the inside of wall framing. Once plastered, these walls will be approximately one foot thick. Clay coating increases fire resistance and reduces problems with pests.

Figure 23. Wall support brackets used to support a roof overhang.

the bulk material.

When it comes to storing fertilizer, salt and other corrosive materials, post-frame buildings are almost always the structural framing/support system of choice (figure 8).

Application 5: Buildings with open walls. Buildings whose only purpose is to provide protection from precipitation and/or solar radiation are generally fabricated with one or more open sides. This would include many commodity (e.g. fertilizer, lumber, feed) storage buildings, animal shelters, and park and other recreational shelters. Open sides facilitate quick building access, which can translate into significant cost savings when handling stored materials.

Unless a unique structural support system has been employed, expect the roof above an open wall to be supported by posts with an on-center spacing of 8 or more feet. Since these posts are seldom laterally supported between their base and crown, they must be designed to resist buckling equally in all horizontal directions. For this reason they tend to be round poles, square solid-sawn timbers, or square glulam or parallel-strand lumber members. Nail-laminated posts will typically require the addition of face plates to obtain relatively equal bending strength in all horizontal directions.

Wood posts in open-front buildings are often preservative-treated because of their direct exposure to “the elements.” However, in situations where wood posts are supported on concrete piers or walls and fairly well protected from precipitation with a roof overhang, preservative treatment may be unnecessary.

Application 6: Buildings requiring interior posts. When a building has interior columns, it is advantageous to use a post-frame building system for two reasons. First, it increases the likelihood that all building support elements will be on similar footings. This speeds construction and minimizes the likelihood of differential settlement. Second, interior posts may be more effectively incorporated into the framing system since they can be aligned with, and then connected via rafters or header beams to exterior posts to form rugged primary building frames.

Interior posts are used in place of interior load-bearing walls, primarily because they provide for a more open floor plan. Money may also be saved by switching from bearing walls to posts, since posts utilize isolated footings which require less concrete than the continuous footings used to support bearing walls.

Interior posts are either used to support roofs in wide buildings or mezzanines (figure 11). In practice, wood-framed roofs that clearspan more than 90 feet and are subjected to heavy snow loads generally will not be economically competitive with steel roof framing unless interior support is provided.

Interior posts are seldom laterally supported between their base and crown, and thus are similar in design to posts in open exterior walls.

Application 7: Buildings with large, clearspan wood trusses with on-center spacing 4 feet or greater. Component connections are critical to the structural integrity of a framing system. In buildings with large, clearspan wood trusses, the most critical connections are those between the truss and its supports. In

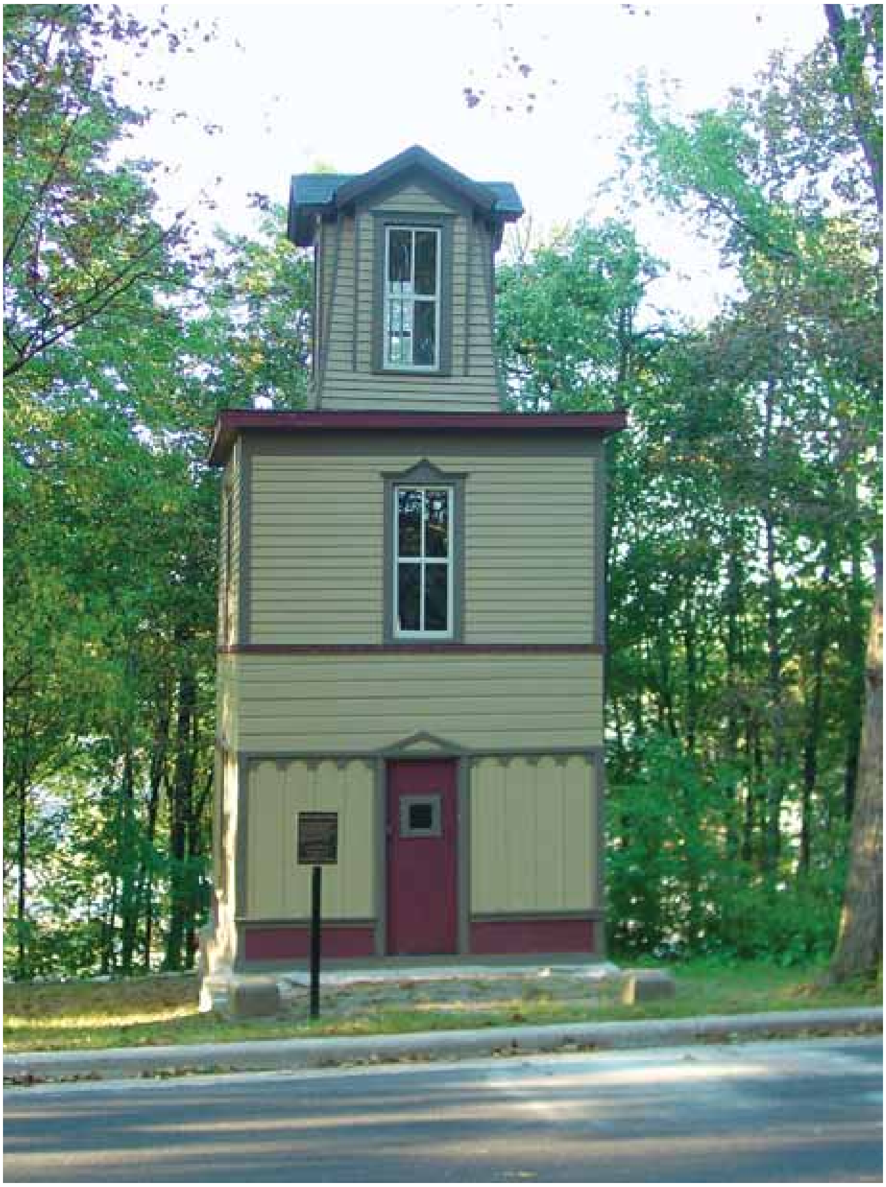

Figure 19d. Tower applications are ideal for post-frame.

Figure 24. Tall walls, large regularly-spaced windows and wall brackets make buildings similar to this good candidates for post-frame.

addition to gravity-induced forces (a.k.a. bearing loads), these connections must resist shear forces acting perpendicular to the plane of the truss and uplift forces due to wind. Depending upon overall building design, connections may also be required to transfer bending moment.

Wood posts enable the fabrication of strong, direct, yet inexpensive connections between large trusses and walls. Exact details for post-to-truss connections vary from designer to designer, and may be influenced by post type. Solid-sawn timber and glulam posts are generally notched to form a truss bearing surface. The truss is rested on notches and bolted into place. A special plate/bracket like that shown in figure 12 may be added to increase connection load transfer capabilities. With mechanically-laminated posts, the truss may rest on a shortened outer-ply or on a shortened inner-ply. The later scenario, which is shown in figure 13, places the bolts in double shear and is a very effective connection.

Application 8: Buildings requiring a more open structural frame to accommodate non-structural "infill" panels/materials. If you visualize replacing all the overhead doors in the mini-warehouse shown in figure 1 with non-load bearing wall materials, you can understand why post-frame is the ideal structural support system for straw bale walls (figure 14), cordwood or stackwood walls, light-clay coated organic fiber walls (figure 16) and even earthen walls. Given that straw, cordwood, clay-coated organic fibers and plain old earth are all considered very environmentally-friendly materials, expect the number of post-frame buildings constructed with in-fill walls of these materials to grow.

When it comes to frame openness, it helps to look at the post-frame building system as a more structurally efficient version of a timber-frame building system. In short, any wall cladding or infill material that has been utilized on or in a timber-frame building may be used on or in a post-frame building. This includes application of structural insulated panels (SIP) to wall and roof surfaces.

Application 9: Stilt buildings. Stilt buildings are among the least expensive options when building in floodplains, over very poor soils or water, on very steep terrain, and in regions of high snowfall.

Stilt buildings fall into two categories: those with stilts that only support sill plates and floor headers, and those with stilts that connect to both roof and floor framing. The latter are essentially post-frame buildings with wood-framed floors. Exactly how a post-frame stilt building would be detailed depends largely on desired floor, wall and ceiling finishes as they control the spacing of structural frame components.

Application 10: Towers and buildings with towers. Towers are a natural fit for wood posts. When posts are properly connected and anchored, very strong and relatively inexpensive three-dimensional tower frames may be built, as evidenced by the many pole-supported forest fire lookout towers built in North America during the early years of the 900s.

Multi-story towers are becoming popular additions to commercial buildings. In addition to adding flare to a building, they frequently serve as stairwells, sources of natural light, clock towers and observatories. Figures 19b and 19d show wood-framed towers and buildings with attached towers.

Application 11: Buildings with post-supported porches, roof overhangs and arcades. Spacing of posts used to support a building's porch, roof overhang and/or arcade (an arcade is a walkway at the edge of a building that has a cover supported by posts) is generally in the 6 to 10 foot range regardless of the building's structural framing/support system. Given that this spacing is typical of the post spacing in most post-frame buildings, there are benefits to using a post-frame building system anytime a building features a relatively long post-supported porch, roof overhang or arcade.

First, it increases the likelihood that all building support elements will be on similar footings. This speeds construction and minimizes the likelihood of differential settlement. Second, posts used to support a porch, roof overhang or arcade may be aligned with — and then connected via — rafters to posts in the exterior wall to form a more efficient structural frame.

Application 12: Buildings with bracket-supported overhangs. Roof overhangs and eyebrow overhangs are commonly added to buildings to improve building aesthetics and durability. They improve durability by protecting door and window openings and siding from precipitation. They also keep snow slides away from the building and limit intrusion of direct solar radiation during warm periods.

As the distance that an overhang extends from the building wall increases, it is more likely the overhang will be supported by a post or wall support bracket (figure 24).

Whether post or wall support brackets are used largely depends on over-

Figure 19b. Tower applications are ideal for post-frame.

hang height. Normally, post supports are used for lower overhangs because of headroom clearance issues when wall support brackets are used.

With higher overhangs, wall support brackets generally look better than posts and are normally less expensive than post supports because of the added foundation and header beams required with post supports.

Wall support brackets are the ideal overhang support system for post-frame buildings in which truss and post spacing are equal. In such buildings, posts and trusses form a series of post-frames as previously described. When wall support brackets are attached to the posts and framing of the overhang, they add rigidity to each post-frame.

In situations where the overhang is a roof overhang, the wall support bracket attaches the end of the truss to the post, thus functioning much like an exterior kneebrace.

Summary

A post-frame building system is one of a number of structural framing/support systems available to building designers. It is unique from other framing/support systems in that its main, load-bearing, vertical framing elements are wood posts. The manner in which posts are spaced, supported and/or otherwise incorporated into post-frame buildings gives the building system inherent structural advantages (translating into cost savings) for these 12 applications:

- Buildings with numerous and/or relatively large wall openings
- Buildings without basements
- Buildings with tall exterior walls
- Bulk storage buildings
- Buildings with open walls
- Buildings requiring interior posts
- Buildings with large, clearspan wood trusses with on-center spacings 4 feet or greater
- Buildings requiring a more open structural frame to accommodate non-structural "infill" panels/materials
- Stilt buildings
- Towers and buildings with towers
- Buildings with post-supported porches, roof overhangs and arcades
- Buildings with bracket-supported overhangs

Post-frame builders can expand their markets by identifying and then actively pursuing building projects associated with one or more of the preceding characteristics. ■