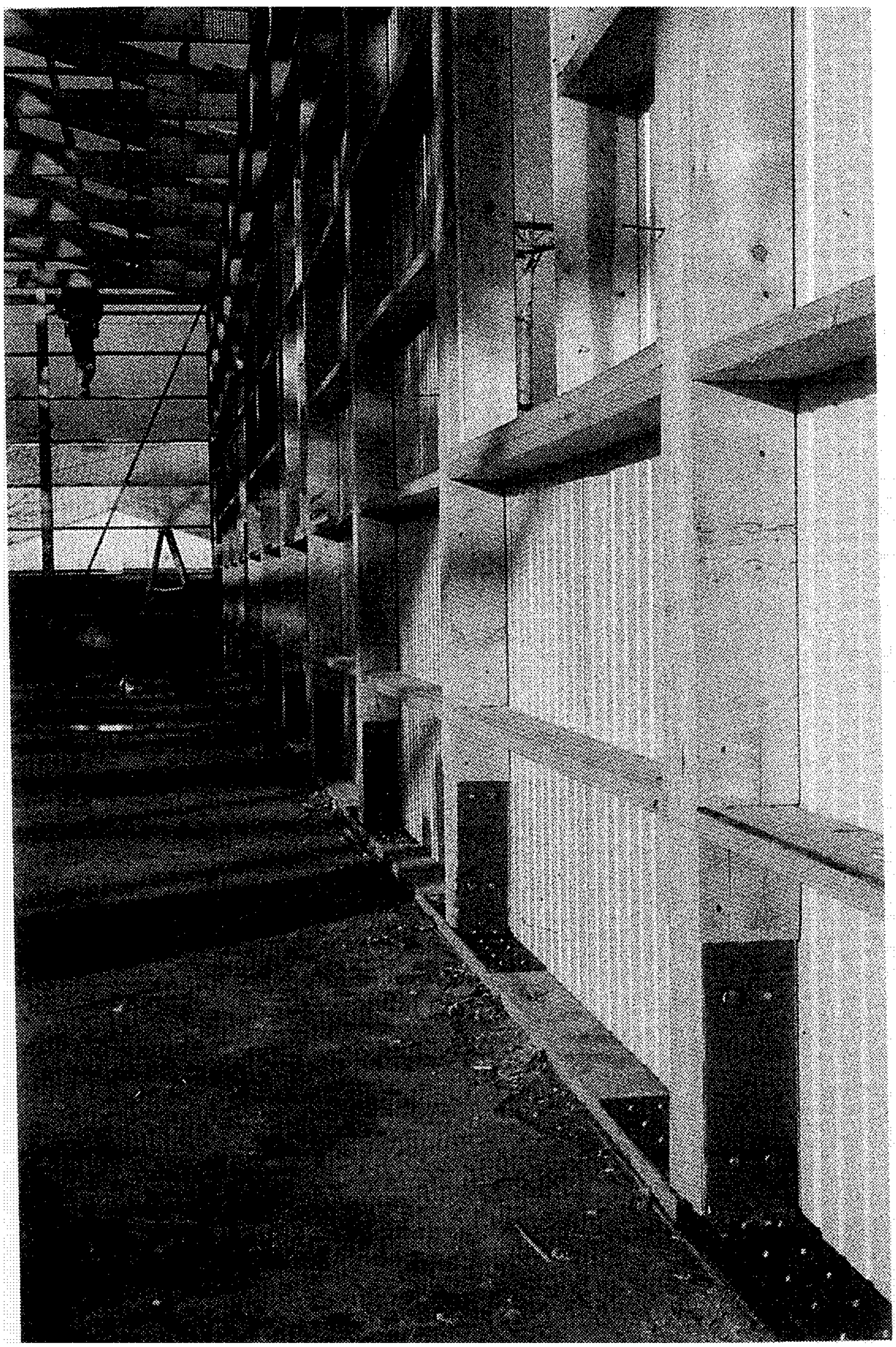
For Post-Frame Buildings

Continuous Concrete Foundations

By Neil F. Meador
and Joe Zulovich

Abstract
There are a variety of situations where a post-frame building on a continuous foundation may be the best building. This article examines the design of post-frame buildings on continuous concrete foundations. There are several alternative ways to design the building. One design example of a post-frame building on a continuous foundation is presented at the end of the article.



Why continuous concrete?
Why would you want to build a continuous concrete foundation for a post-frame building? The continuous concrete foundation seems to cancel many of the advantages of a post-frame building. The decreased cost of building a post foundation, the moment resistance obtained by embedding a post into the ground, and the ability to construct a post-frame building almost any time of year are the advantages you lose when you build a continuous concrete foundation for a post-frame building.

However, the owner or a building code official may require a continuous concrete perimeter wall as a method of ratproofing, water proofing, or for providing protection against decay. Or, the plan may call for a perimeter concrete wall to function as a basement wall, storage pit wall, earth retaining wall, or wall to confine stored products. A continuous concrete perimeter wall may also be selected when the lower portion of the wall must withstand mechanical abuse from forklifts or adverse environmental conditions such as confining hazardous chemicals. Whatever the function for the perimeter concrete wall, it may be economical to also use the perimeter concrete wall as a foundation wall for the post-frame building.

If continuous foundation, why post-frame construction?
One may ask, "Why put a post-frame building rather than a stud wall on top of the continuous foundation?" Some of the advantages of post-frame buildings are lost when placed on a continuous foundation as indicated earlier in this paper. However, a building contractor may prefer post-frame buildings because designs

are already available, construction crews know how to construct post-frame buildings efficiently, and wide spacing of trusses and wall supports may fit very well into the planning of a particular building.

If the decision has been made to build a continuous concrete foundation wall and footing with a post-frame structure, the following construction alternatives should be considered:

1. Incorporate the post-frame post into the concrete foundation wall.
2. Place the post-frame building on top of the continuous foundation wall.

Alternative: Integrated Concrete Wall and Posts

One way to integrate the post and the concrete wall would be to cast the foundation wall around the wood post. However, because of the size of most wood posts, concrete cover for the wood post and room for reinforcing steel would make the foundation wall 10 inches or more wide — or the wall could be formed around the post. Another way to integrate the post and concrete wall is to use the standard post and post footing with a concrete foundation wall placed between posts. This alternative may not fulfill the continuity required due to separation at the post-concrete wall interface. To alleviate this separation problem, concrete reinforcing may be continued from the concrete wall on one side of the post through holes drilled in the posts to the concrete wall on the other side.

The integrated post and foundation wall may not provide the same lateral stability to the building as the post-frame building. Support provided to the post by interaction of the foundation wall and the soil is not the same as in the usual post-frame building where the overall building stability should be analyzed. Although this option may be difficult to build and may not give the same lateral support to the building, it may still be the best alternative for particular situations.

Alternative: Post-Frame on Top of Continuous Foundation Wall

An alternative that would appeal to many is to place the standard post-frame building on top of the continuous concrete foundation wall and footing. Although a particular post-frame design was structurally adequate when the posts were embedded in the soil, it may not be adequate when placed on top of the continuous concrete foundation wall and footing. In the standard post-frame structure, posts embedded in the ground provided the lateral resistance necessary for stability of the building. The post and post footing provided anchorage against uplift caused by wind. The ground below the post footing provided bearing resistance for downward loads and protection against frost heaving. A post on top of a continuous concrete foundation can be designed to provide adequate support for the post-frame building. However, the entire building must be designed to be laterally stable, be anchored against wind uplift and have adequate soil bearing capacity free of frost heaving.

Consider first the building lateral stability (the resistance of the whole building to horizontal loads). The way the building resists lateral loads is greatly influenced by the moment resistance of the connection between the foundation wall and the post. This post-frame can be designed assuming the post-foundation wall connection has no moment resistance (pinned) or for moment resistance equal to the moment resistance of the post.

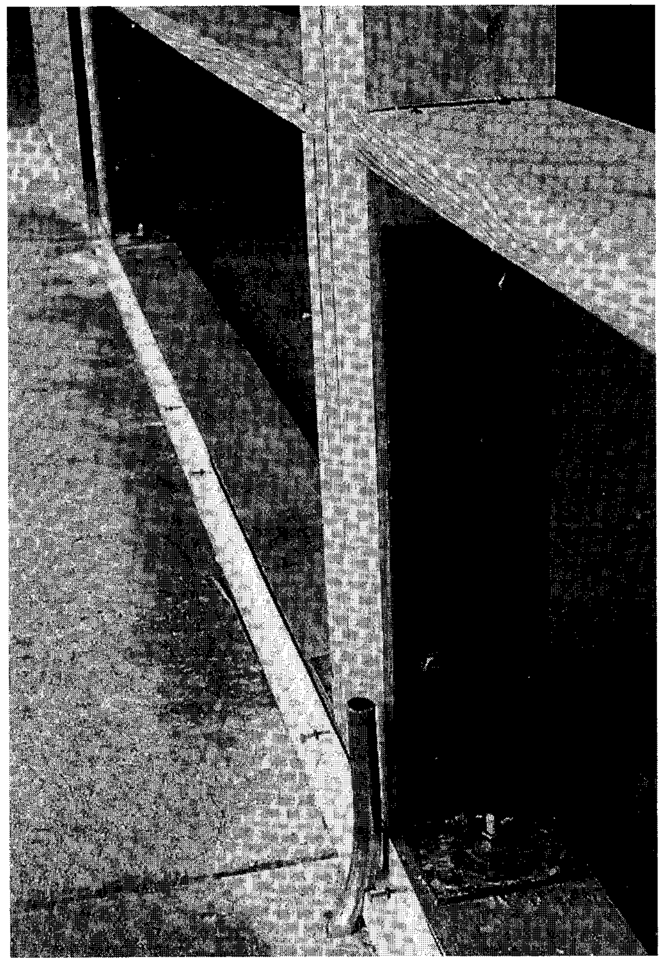
Comparing the cases of a moment resistance connection to the pinned connection, the moment resistant connection increases the maximum horizontal force on the foundation wall and reduces the horizontal force that must be transmitted through the roof diaphragm to the end and partition walls (shear walls). If the lateral force on the foundation wall is a problem and building lateral stability can be gained easily through shear walls, then the pinned connection would be the best choice. If each section of the building must provide building lateral stability independent of any diaphragm action, then the connection should be moment resistant or braces used to supply the lateral resistance.

For an example of the magnitude of moments and forces the post-foundation joint must resist, consider a 40-foot wide building with an 8-foot sidewall height (above the foundation wall), 7.5-foot post spacing and a 4-in-12 slope gable roof. Let us assume this building is subjected to 20 pounds per square foot wind load on the building horizontal projection. If the post-foundation joint is to provide the moment necessary for lateral stability (no diaphragm action assumed) the post-foundation connection must be capable of a 45,612-inch pounds moment and 835 pounds horizontal force on the foundation wall at each windward wall post.

The moment to be resisted by the post-foundation connection is very significant and presents a complex joint design problem. If the post-foundation connection has no moment resistance, the roof diaphragm and shear walls must resist a horizontal force of 920 pounds per frame and a horizontal force on the foundation wall of 360 pounds at each windward post. In this case, the roof diaphragm and shear walls must be carefully designed.

Next, consider the post-bearing on the continuous foundation wall. The continuous foundation wall is usually designed for studs 16 inches to 2 feet on center, therefore, the vertical load on the foundation wall is almost uniform. However, with a post-frame structure, the vertical loads are much larger and are applied at spacings from 4-to-12 feet or more on center. This less uniform loading on the foundation wall causes the foundation wall to act as a beam. As a beam the foundation wall must resist the resulting shear and bending stresses. There also would be less uniform pressures on the earth below the footing.

Considering a 48-foot clear span building with 7-1/2-foot spacing between posts and 25 pounds per square foot live plus dead load, the downward force per post is 4,500 pounds. If the wood column bears on concrete, steel plate or wood plate, the lumber parallel-to-grain stress or the perpendicular-to-grain stress in the wood plate is the limiting factor. Therefore, for gravity load design, the wood column must be designed and the post-bearing on the wood plate must be checked.



From the example above, and assuming an allowable concrete shear stress of 100 psi, the maximum shear force would be half of the downward load per post times. A load factor of 1.7 or 3,825 pounds and a foundation cross sectional area of 38.25 square inches would be adequate to prevent failure due to shear of the foundation. Therefore, given the usual wall width of 8 inches, it appears that the concentrated loads from the posts should not be a problem considering concrete shear.

How the wall is constructed will determine whether the post needs to be pressure treated. Some instances where the BOCA code requires posts to be pressure treated include:

1. Posts bearing on the concrete foundation within 8 inches of the earth.

2. Posts embedded in concrete that is in contact with earth or exposed to weather.

3. Posts in contact with the earth.

4. Posts exposed to the weather.

The level of treatment varies with the exposure conditions for the post. Treatment levels should follow the recommendations of the appropriate American Wood Preserver's Association Standard.

Consider the bearing of the foundation on soil. With the concentrated loads from the posts at much greater intervals than in stud wall construction, there is a tendency for the pressure underneath the foundation wall to be

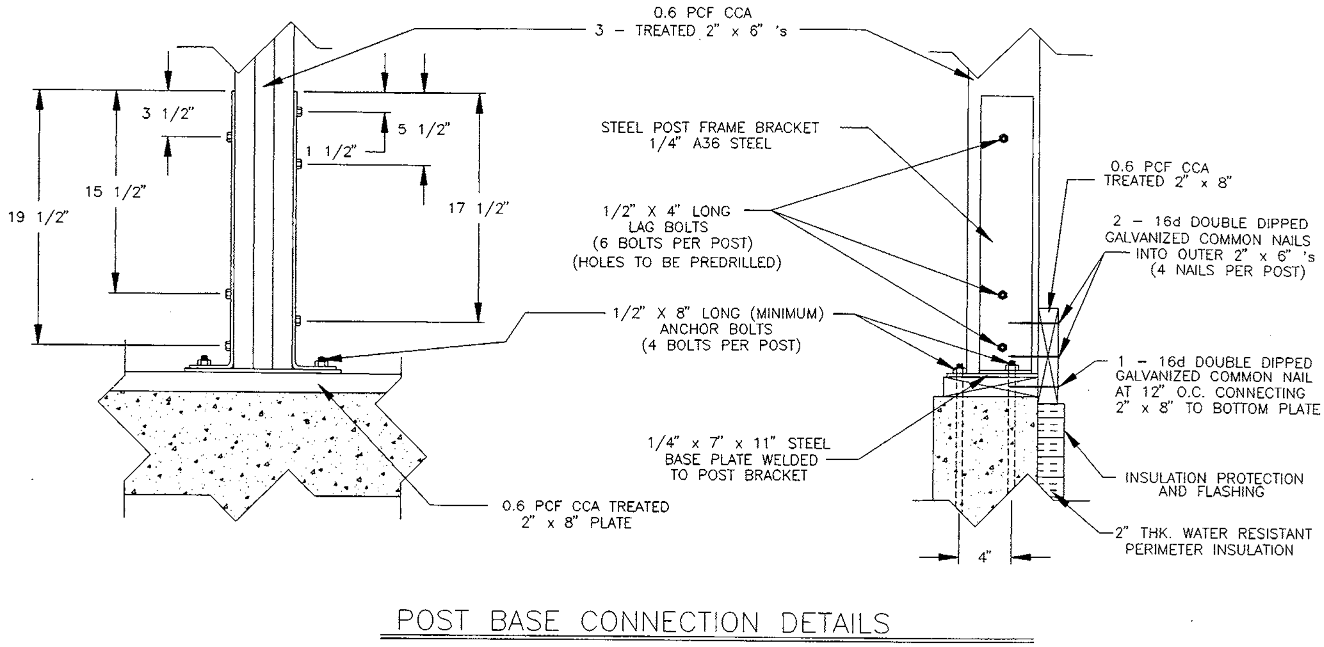


Figure 2, MO-Flex Building Post-Foundation Wall Connection Detail.

greater below the post. This higher pressure may cause more settlement in that area and have a tendency to crack the footing and foundation wall between posts.

One way to alleviate this problem is to increase footing width in that area. However, predicting the magnitude of the increased soil stress under the post is difficult and construction of a non-uniform width footing may be expensive. It may be easier to make the foundation wall and footing stiff enough so that deflection and unequal pressure on the soils is not a problem. A way this can be accomplished is to make that foundation wall a reinforced concrete beam with steel located in the top and lower portions of the wall. This steel, acting with the concrete, will make a very stiff concrete beam that will resist deflection and cracking.

Analyze the wall as a reinforced concrete beam to determine the correct amount of steel. The minimum horizontal steel, #5 or smaller bars, required by ACI 318-89 (Revised in 1992) in foundation walls for temperature stresses is 0.20 percent of the total cross sectional area, and this amount of steel may be adequate; however, it is suggested that the steel be located with a disproportionate amount in the bottom and top of this foundation wall. Also, design the foundation wall for bending moment due to the moment from the post, horizontal force at the top of the wall and earth or stored material lateral pressures against the wall. A minimum vertical steel required by ACI 318-89 (Revised in 1992) for temperature stresses (#5 and smaller bars) is 0.12 percent.

Missouri Mo-Flex Plans

Shown on page 68 is the MO-Flex wall section for a post-frame building on a continuous foundation. Note that the MO-Flex plans differ in design criteria than the previous example in this paper. This building plan is for one of a series of swine confinement buildings created by Dr. Joe Zulovich, Agricultural Engineering Department, University of Missouri. The building plans are part of the MO-Flex Swine Building System. Each plan can have a manure handling pit or flush gutter along the exterior wall. For this reason, Dr. Zulovich chose a continuous concrete foundation. For the structure above, post-frame construction was selected for economy.

This series of building plans use the same construction with different building lengths and different interior arrangements. Because the building length was variable and interior walls or braces could interfere with a flexible interior arrangement, the building was designed so that each section of the building was laterally stable without considering diaphragm action.

As an example of a post foundation wall connection design, shown on page 67 is the MO-Flex post foundation wall detail. More detail, including design limitations, can be obtained by ordering the MO-Flex plans from the Agricultural Engineering Plan Service, Agricultural Engineering, University of Missouri, Columbia MO 65211.

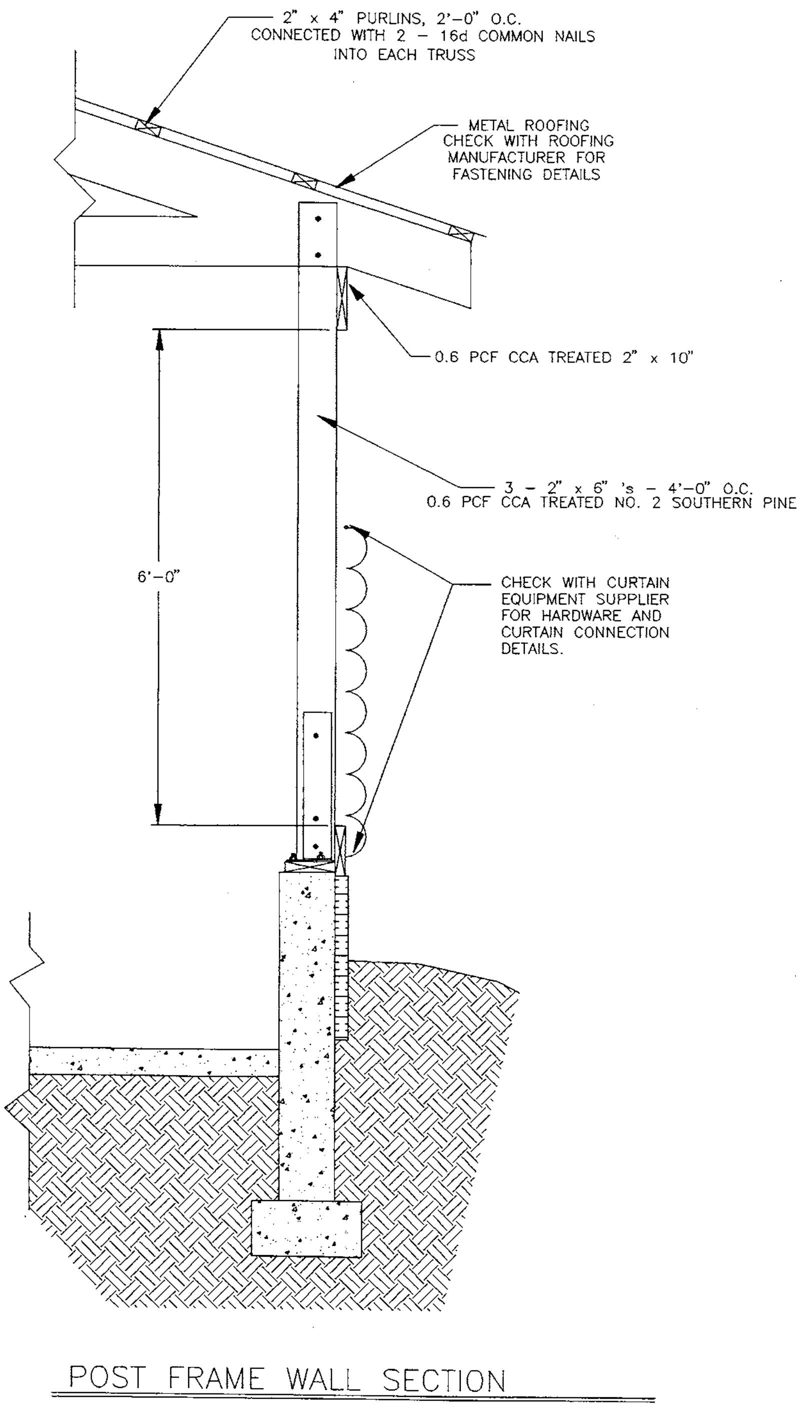


Figure 1, MO-Flex Building Wall Section.

Conclusion

Situations exist where a post-frame building with continuous concrete perimeter walls is the best building design. Two ways to design this type of building are to:

1. Integrate the post and continuous concrete wall.
2. Build the post-frame building on top of the continuous concrete foundation wall.

In both cases the building resists horizontal and vertical loads differently than a post-frame building. Therefore, care must be exercised to insure that the design is structurally adequate. For the integrated post and concrete wall, tying the wall and post together allows the wall to resist horizontal loads by bearing against floors and/or earth and to resist vertical forces by the usual post footing or by a wall footing. For the post-frame structure on a continuous concrete foundation wall, lateral loads on the building can be resisted by:

1. Making the post-foundation wall joint moment resistant.
2. Relying on roof diaphragm action to distribute the horizontal forces to shear walls.
3. Bracing.
4. Combining any of these three methods.

The foundation wall can resist horizontal forces at the top of the wall and moments applied to the wall by bearing on floors and earth. Vertical loads can be resisted by the wall if it is designed as a deep beam that resists shear forces and moments caused by the concentrated loads and differential settlement. With careful design, a post-frame building with a continuous perimeter wall can be structurally adequate and should be considered when functional or other requirements make this type building advantageous.

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don't realize their assets might have to be sold at "fire sale" prices in order to raise the cash that will be used to settle the estate. There is never too much liquidity. On the other hand, lack of liquidity can devastate an otherwise well-designed plan.

5. Uncle Sam's financing.
Some real estate is subject to favorable valuation rules for estate tax purposes. The law allows the estate to defer the payment of estate taxes for up to 14 years, if certain conditions are met. Unfortunately, this is often an estate tax trap, because the rules can be so harsh. For instance, over the 14-year period, the amount of estate tax actually paid, including interest, is usually double the amount originally owed. In addition, the entire tax owed will come due if any installment payment of tax or interest is missed. Also, during the period of the defferal, the Internal Revenue Service has a lien on the property. You can imagine how an IRS lien might make it difficult to raise additional funds for expansion, or make things complicated in times of financial stress.

6. Improperly arranged life insurance.
Even when there is an adequate amount of insurance in the estate to provide proper liquidity, often times the insurance is improperly arranged. Take these examples: perhaps there is no contingent (i.e., back-up) beneficiary named, or the proceeds of the policy may be included in the estate of the insured. Again, this can devastate an otherwise well-conceived plan.

7. Will errors.
Often people have their wills done and forget about them. This is a mistake. Any major change in circumstances, such as the birth or death of a child, the marriage, divorce, or separation of anyone named in the will, or any major change in the tax laws, is an indicator that the will should be reviewed.

8. Improper disposition of assets.
This occurs whenever the wrong person receives the wrong assets at the wrong time. For instance, this can occur when a surviving spouse inherits a complex estate at a time when he or she is unprepared or unwilling to handle it. Another example is when a sizable estate is left outright to a teenager or very young adult.

9. Lack of asset protection.
In our lawsuit-crazy society, asset protection planning is critical, especially for those with large estates. It is not uncommon for someone to work their entire life to building a sizable estate, only to see it jeopardized by a lawsuit. Proper asset protection can provide great peace of mind and can stop a lawsuit dead in its tracks. Unfortunately, in this area of estate planning, asset protection is usually overlooked.

10. Reliance on non-experts.
The estate planning process is complex. That is why it's important to work with an attorney, CPA and other financial advisers who understand complete estate planning. This is not an area where you want to rely on someone who's dabbling. It's a full-time discipline, and you should rely only on the advice of those who fully understand it.

11. Failure to update the estate plan.
I've hinted at it several times throughout this article, and I've listed it here because it's such a major concern. Even the most well-conceived estate plan needs to be updated any time there is a major change in your circumstances or in the tax laws. Given the rate at which things change in Washington these days, you should review your plan with your adviser at least every two years.

While identifying the most common estate planning mistakes is helpful, that is only the first step. Equally important is that you act on this information. That way you and your family will have greater security and peace of mind. For a free recorded message and a copy of my special report titled, *How to Legally Keep the IRS and the Attorneys out of Your Pocket,* call me at (800) 788-9528, 24 hours a day.

'Post-Frame' Gets Award

The American Society of Agricultural Engineers (ASAE) will present its Historic Agricultural Engineering Landmark award to the post-frame building. The National Frame Builders Association will accept this award on behalf of the industry.

The special presentation will be held at the general session ceremony on the opening day of the National Frame Builders Conference and Rural Builder Show, Wednesday, Feb. 15, at 9:20 a.m.

The E ASAE Historic Agricultural Engineering Landmark award commemorates significant past accomplishments with appropriate landmarks.