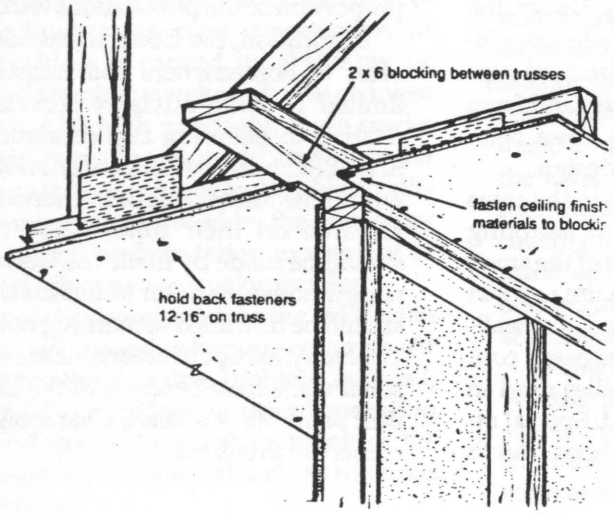
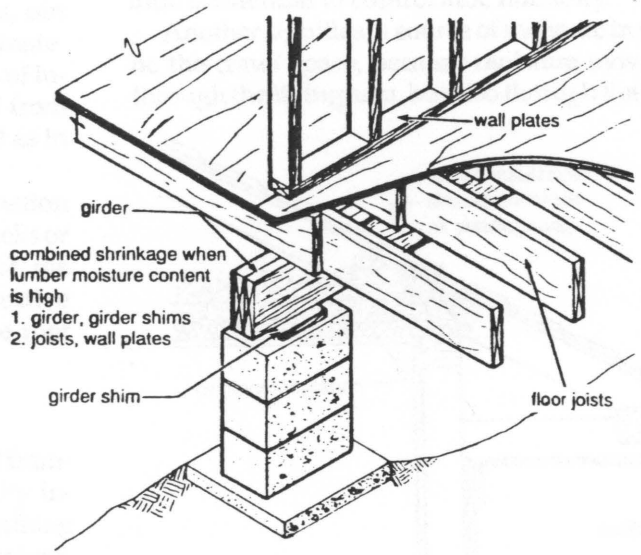
Technical Note 18

Ceiling-Floor Partition Separation: What Is It and Why Is It Occurring?





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Many of the Council's studies have been in the areas of simplifying construction methods and adapting large-scale building techniques to the needs of the small builder. Of particular importance has been the work in roof-truss and floor-truss construction, and the wall-panel framing system. One of the major research concerns has been with how much space families need in their homes and how it should be arranged. Special attention has been given to the design of kitchens, and to energy conservation and solar utilization.

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Ceiling-Floor Partition Separation: What Is It and Why Is It Occurring?

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This publication is intended to increase the understanding of cracking or separation of finish materials occasionally found in light-frame wood construction. In many cases, the problem is caused by shrinking or swelling of the wood framing members due to changes in moisture content. Although unsightly, these cracks and separations are basically cosmetic and pose no structural problems. It is important to be able to differentiate between movement caused by the instability of wood and that caused by foundation movement or structural failure, which can cause major problems.

With the advent of the energy crisis in the 1970's, the use of large amounts of insulation became common. At about the same time, the cracking problem evolved, which I generally call Ceiling-Floor Partition Separation (CFPS). Cracks developed in the finish materials or between the ceiling and the partition walls, or between the floor and the partitions.

Even though the wood roof truss is by far the most common method of roof framing, cracks and separations cannot be attributed exclusively to wood trusses. Other types of wood construction, such as joist and rafter framing, and the more recent wood I-joists, can show cracking or bowing. CFPS is found predominately in the colder climates and where greater depths of insulation have been used. CFPS has been reported from Denmark, Sweden, England, and Canada, as well as in the United States.

CFPS can be the result of one factor or a combination of things happening at the same time. Because cracks or separations caused by changes in dimension of the wood components are temporary, required corrective measures should not include replacement of the roof system.

Attic Moisture

High humidity in the attic space will cause wood framing members to absorb moisture. If the humidity increases to the point of condensation on roof sheathing and framing members, the wood can approach saturation. The top chord of a truss can absorb moisture and expand, while the bottom chord, buried in insulation and absorbing heat from the living areas below, can dry to a low moisture content and shrink. The primary change in dimension of wood with change in moisture content is in width and thickness. However, there is also some dimensional change in length as well, the amount depending upon the species and where in the log the member originated. Therefore, the combination of these two opposing actions, reduction of moisture in the bottom chord and absorption in the upper chord, can cause the truss to bow or arch upward. In the summer, the solar heating of the attic can dry the exposed framing, causing the truss to return to its original position. The same action can occur in ceiling joists partially imbedded in insulation. A brief discussion on longitudinal shrinkage can be found in the Appendix.

Humidity problems can be caused from improperly venting the bathroom and kitchen vents into the attic space. Even more serious is the discharge of moisture from the clothes dryer into the attic. Venting moisture sources into the attic should not be allowed.

When adding insulation to an existing attic, soffit vents are often inadvertently closed off or covered, which blocks the path of air movement through the attic, as shown in Figure 1. Adequate ventilation of the attic is essential to control attic humidity.

Another significant source of moisture in the attic can be the crawl space, because moisture moves not only through the living area, but also through the stud spaces

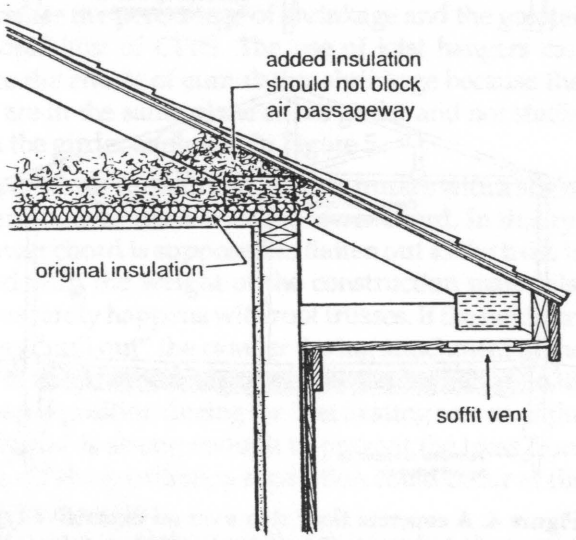


Figure 1. Insulation may block air movement from the soffit vents into the attic space.

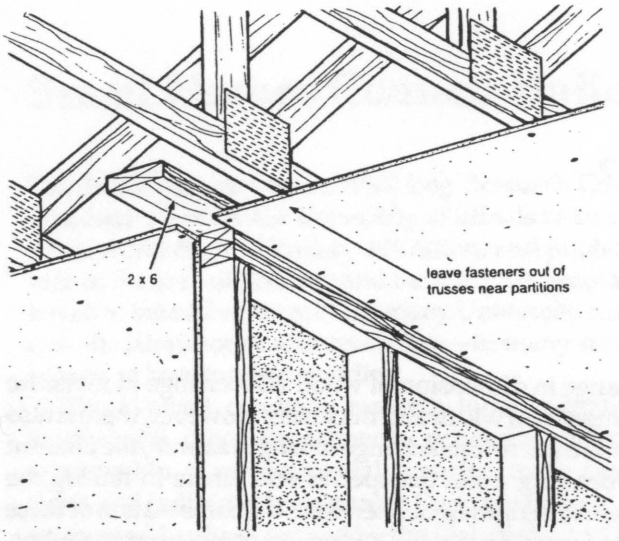


Figure 2. When the trusses are parallel to the partitions, install 2x6 nailers for fastening the ceiling materials. Do not nail the ceiling material to the bottom chords near partitions.

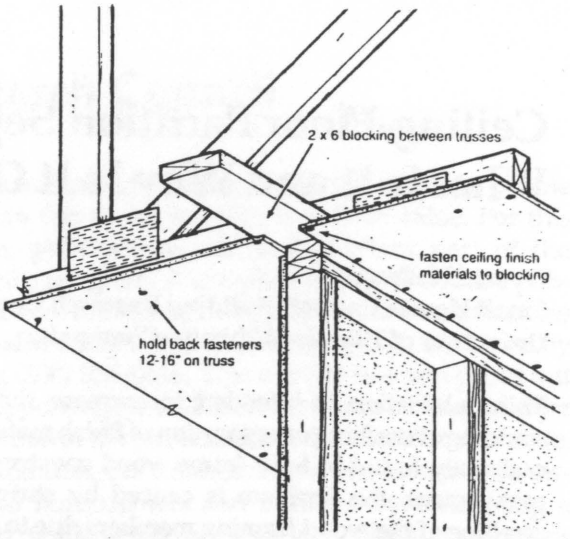


Figure 3. When the trusses are perpendicular to the partitions, install "dead wood" blocking to attach the ceiling finish material. Do not nail the finish material to the truss chord for 12-16 inches on either side of the partition.

of the walls and interior partitions, particularly plumbing walls. The crawl space should be vented through foundation vents if there is a moisture problem, and the soil surface should be covered with a polyethylene vapor retarder. Providing proper outside grading (six inches of slope away from the foundation in the first ten feet) will move rain water away from the structure and reduce seepage through the foundation walls.

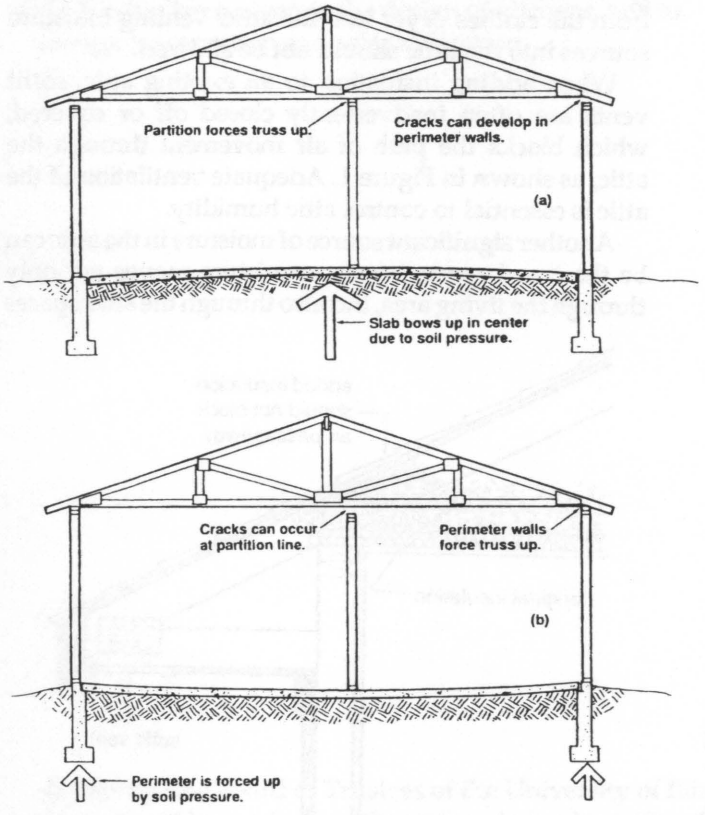


Figure 4. A concrete floor slab over an expansive-type clay soil can (a) bow up in the center, or (b) rise at the perimeter. Either can cause CFPS.

Ceiling Drywall Nailing

Nailing the ceiling drywall directly to the bottom chord of the truss near the partition can increase the probability of visible cracking. If any shrinkage or movement occurs, cracks can develop at the partition line. One suggested construction practice is to install "dead-wood" blocking to the top of the partition wall plates between the trusses. These blocks provide a nailing surface for the drywall. The drywall is not nailed to the bottom chord of the trusses for 12-16 inches from the partition, as shown in Figures 2 and 3. Several proprietary clip-type devices have been developed to take the place of "dead-wood" blocking, but I have no first-hand personal evaluation or research information on these devices.

The amount of heat absorbed by the lower chord of the truss or ceiling joist can be reduced by installing rigid insulation board between the drywall and the chord or joist. The insulation should be fastened to the blocking as well.

Other Causes

While research has shown that some ceiling joists, I-joists, and trusses actually do bow or arch upward, there are several reasons not necessarily associated with trusses which can cause CFPS to occur. Following is a list of other known causes, which do have implications of structural problems, with some recommendations to reduce the possibility of cracks and separations.

Foundation Settlement. Settlement of the floor girder support pads and the effects of freezing/thawing on the

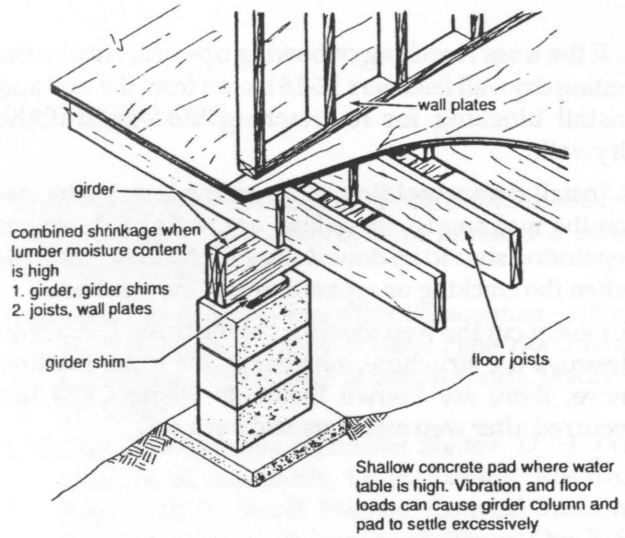


Figure 5. Crawl-space details such as this have the potential for cracks and separations.

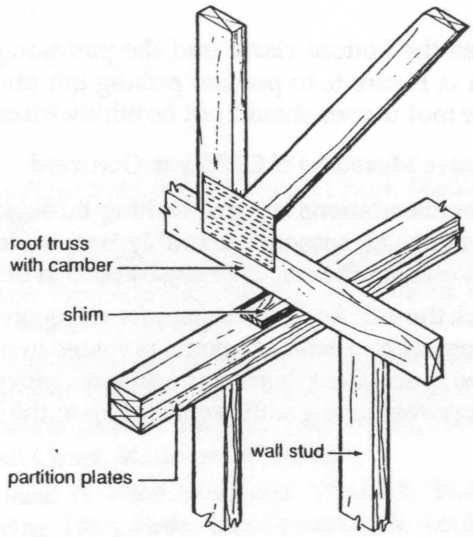


Figure 6. If the roof trusses are fabricated with a camber, shims should be installed between the bottom chords and the partition plates to prevent pulling out the camber.

perimeter foundation can produce the same effect at the junction of the ceiling and partition walls as truss arching. Foundation details are important. Footings which extend below the frost or freeze line are essential to prevent frost heave, particularly if the building is left unheated during part of a winter season. A second source of movement may be the method of supporting the floor girders in crawl-space construction, especially in areas with a high water table. The footings under the girder columns should be large enough to prevent settlement or tipping in the soft soil, which may become plastic under load.

Expansive Soils. Movement of concrete slabs built on expansive-type clay soils also can cause cracks and separations. Shrinking or swelling of expansive clay soils can cause a concrete slab to either bow upward near the center or raise around the perimeter of the structure. This is caused by differences in the moisture content of the soil. These expansive soils are most prevalent in the semi-arid regions of the country, running from the eastern two-thirds of Texas into Louisiana and northwest through the great plains. They also occur in some parts of California. Expansive clay soils exhibit the most extreme movement in areas which have relatively heavy rainfall for short periods of time followed by lengthy periods of dryness or only slight rainfall.

In truss-roof structures with partitions essentially near the center, cracks can occur at the ceiling line of the exterior walls if the slab bows up, as shown in Figure 4a. On the other hand, if the soil around the perimeter expands, one or both ends of the truss can be raised, causing cracks to develop at the ceiling line of the partition walls and the truss, as in Figure 4b. As the soil moisture equalizes, the slab may return to its normal position and the cracks close.

Wood Shrinkage. Excessive shrinkage of the wood framing members, including the girders, girder shims, sill and perimeter wall plates, floor joists, and partition wall plates, can also cause symptoms similar to truss rise. Figure 5 shows a typical crawl-space detail where excessive shrinkage and settlement can cause cracks and separations.

To prevent problems from this source, the builder should use lumber that has been properly dried, then properly protected during shipment, storage and handling. When preservative-treated lumber is used for sill plates, less shrinkage occurs if the material has been redried after treatment.

Deliveries to the job site should be carefully scheduled to reduce the length of time the components are exposed to the elements. The higher the moisture content of the lumber at the time the building is covered, the greater the percentage of shrinkage and the greater the possibility of CFPS. The use of joist hangers can reduce the effects of cumulative shrinkage because the joists are in the same plane as the girder and not stacked on the girder as shown in Figure 5.

Camber. Some truss firms fabricate trusses with a slight upward bow or camber in the lower chord. In theory, the lower chord is supposed to flatten out as the truss is loaded with the weight of the construction materials, but this rarely happens with roof trusses. If the field carpenters "pull out" the camber during attachment of the truss to the partition, the truss may tend to return to its cambered position during the first heating season. If the attachment is strong enough to prevent the truss from lifting off the partition, a separation could occur at the partition-floor line.

If the trusses are fabricated with a camber, the recommended practice is to install thin shims or spacer blocks

between the bottom chord and the partition plate, as shown in Figure 6, to prevent pulling out the camber. Shorter roof trusses should not be built with camber.

Corrective Measures if CFPS has Occurred

1. Recommendations suggest waiting through at least the first heating season, preferably two, to determine what is causing the cracks or separations to develop.

2. Check the attic and crawl space for adequate ventilation. Remove any exhaust openings vented into the attic or crawl space. Vent them to the outside. Move any insulation covering the soffit vent system in the attic.

3. If the truss is arching or bowing upward, remove the ceiling drywall fasteners 12-16 inches from the wall and install blocking for re-attaching the edges of the drywall.

4. Install crown molding at the ceiling line. (Note: fasten the molding to the ceiling, not walls.) Subsequent repainting should be done during the heating season or when the cracking or separation is at the maximum.

5. Do not cut the web members of the truss. This action destroys the structural integrity of the truss. Furthermore, there are known incidents where CFPS has recurred after web members had been cut.

References

Further reading on the subject can be found in the following technical publications, with Number 8 being especially valuable:

1. *Ceiling-Floor Partition Separation Phenomenon - A Survey of the Problem.* The 1979 Metal Plate Wood Truss Conference. FPRS, 2801 Marshall Court, Madison WI 53705.
2. *Ceiling-Floor Partition Separation Studies.* D. H. Percival, S. K. Suddarth, Q. B. Comus. Research Report 82-2, Small Homes Council-Building Research Council, University of Illinois, One E. St. Mary's Rd., Champaign, IL 61820, 217-333-1801.
3. *Design and Construction of Post Tension Slabs on Grade.* Post Tension Institute, 302 W. Osborne, Suite 3500, Phoenix, AZ 85013.
4. *Juvenile Wood as a Source of Seasonal Arching in Trusses.* Thomas M. Gorman. *Forest Products Journal,* Nov/Dec. 1985. FPRS, 2801 Marshall Court, Madison WI 53705.
5. *Longitudinal Moisture Response in Truss Lumber - A Potential Cause of Ceiling or Floor Partition Separation.* D. H. Percival, S. K. Suddarth. *FPRS Journal,* Nov/Dec 1983, 2801 Marshall Court, Madison WI 53705.
6. *Longitudinal Shrinkage of Wood.* Report No. 1093. U.S. Forest Products Laboratory, One Gifford Pinchot Dr., Madison WI 53705.
7. *The Mechanism of Ceiling-Floor Partition Separation.* Stephen Quarles and Robert Erickson. *Forest Products Journal,* August, 1987. FPRS, 2801 Marshall Court, Madison, WI 53705.
8. *Movement in Wood Structures.* David B. Brakeman. Spring 1988, *Peaks,* Lumbermate, St. Louis, Missouri.
9. *Weak Wood - Fast Grown Trees Make Problem Lumber.* J. F. Senft, B. Alan Bendtsen, W. L. Galligan. *Journal of Forestry,* August, 1985.
10. *Understanding and Designing Light-Frame Structures to Reduce the Possibilities of "Ceiling-Floor Partition Separation."* D. H. Percival, *Wood Words,* WTCA, 111 E. Wacker Dr., Chicago, IL 60601.
11. *Upward Deflection of Wood Trusses in Winter.* W. G. Plewes, Division of Building Research, National Research Council of Canada, Ottawa, Canada.

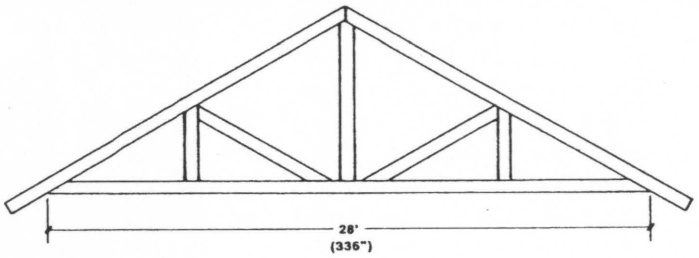
Appendix

The upward deflection of a truss as a result of longitudinal shrinking or elongation can occur because the lumber is firmly restrained by "rigid" connections and with any shortening of the lower chord or lengthening of the upper chords, or both, the truss could bow upwards. The loss of moisture could cause a slight shortening of the lower chord, forcing the truss upwards while an increase in moisture in the upper chords could cause lengthening and enough force to pull the truss upward.

This table shows the average, extremely small longitudinal shrinkage values of three lumber species commonly used in construction.

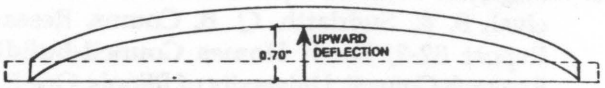
SYP = 0.0127%
D. Fir = 0.0073%
W. Hem.= 0.0063%
} for each 1% loss in M.C.

For example, consider the lower chord of a 28-foot SYP truss, deeply embedded in insulation. Absorbing heat from the living area below, the lumber can dry down to 7% from 19%, a difference of 12% M.C.



0.0127 x 12 = 0.0152
0.0152 x 336" = 0.51"
(shortening)

In terms of the mathematics of a circle, shortening the bottom chord 0.51" can produce the arc of a circle with a 0.70" upward deflection from a straight line.



However, because of variations between species, variation between trees from different locations in the forest, the age of the trees when cut, and variations in the lumber from the same tree, shortening and lengthening does not always take place uniformly, and sometimes not at all. In addition, slight slippage of the wood around the metal teeth of the truss plate, the orientation of the growth rings in the lumber, the number of pieces used to form the lower chord, the way the trusses are fastened to the walls, the amount of ventilation, the relative humidity, the thickness of the insulation, along with the other factors discussed earlier, make predicting when CFPS will occur almost impossible.