# Movement In Wood Structures

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The fact that buildings are in motion should really not come as a surprise to most people. Wood doors, drawers and windows can stick when the humidity is high, and then move freely again when the weather turns dry. Metal and vinyl siding can buckle and warp from thermal expansion in hot weather. Cracks can be found in almost every concrete slab and masonry wall. All of these things are common everyday evidence of motion in structures.

In light frame construction, the evidence of motion is usually a crack or break in a brittle or low strength material. When the structure moves, these materials are stressed to their breaking point as they try to resist the forces causing the movement.

So what does this really mean? It means that cracks develop in drywall joints, in the drywall board itself, in hard floor coverings, in plastic laminates, in the mortar joints of a brick fireplace hearth, and so on. These problems often fall into the category of the so-called ceiling-floor partition separation (CFPS) phenomenon. Sometimes truss arching is part of the cause; sometimes it is not. Keep in mind that truss arching is only one of a number of causes of CFPS.

There are a number of causes for movement in wood structures. The four most common causes are shrinkage, swelling, deflection under load and construction practices. Also, the chances are good that more than one of these mechanisms is involved when evidence of movement is found. It is easy to place the blame for a problem on a single cause, but it usually isn't that simple.

## SEPARATING THE CAUSES

It was a survey of structures conducted by Percival and Suddarth[1], that identified the causes which are now generally believed to cause CFPS. These causes have been separated into several general categories. In real structures however, the causes are usually inter-related and don't separate cleanly.

### ○ Shrinkage Of Framing Lumber

In light frame construction, the lumbers used for wall studs, bearing plates, floor beams and floor joists will have to dry out further before they reach an equilibrium moisture content. This is true even for kiln dried material. It just isn't economical or practical to dry lumber that much and then try to keep it that dry before a building can be closed in. Though each piece may shrink only a small, even imperceptible, amount when enough of them are added together, the movement can be obvious.

Wood shrinks more across the grain than it does along the grain. Relatively speaking, the width and thickness of a board will shrink more than its length. This means that shrinkage in the width of beams, joists and wall plates will probably cause more movement than the shortening of the studs. Places where several wall plates are stacked on top of floor joists, which sit on a wood beam, which is shimmed to a support with several blocks of wood, are the places that will move the most due to shrinkage.

### ○ Shrinkage Of Truss Lumber

Even though lumber shrinks the most across the grain, it is the longitudinal (along the grain) shrinkage that can cause movement in trusses. This movement will result in truss arching under certain conditions. When the top and bottom chords are in different temperature and humidity conditions, their moisture content will be different. Typically, the bottom chord of a roof truss will be kept warm, and thus dry, by the attic insulation around it. The top chord will be cold and thus more moist than the bottom chord because of high relative humidity in the attic or even condensation of moisture on the cold surfaces. The drier bottom chord will shrink more than the top chord and in fact, the top chord could actually take on moisture and swell to a longer length. The top chord resists the shortening of the bottom chord and the bottom chord resists the lengthening of the top chord, or both. This action develops forces internal to the truss that can be large enough to make it arch.

Some things are known to increase a trusses' potential for arching. Juvenile wood and compression wood are known to shrink and swell more than normal growth wood. These types of wood characteristics are infrequent and are very difficult to visually differentiate from normal wood. When these types of woods are in truss chords, the internal forces generated by changing humidity and temperature are greater, because the movement is greater.

Another consideration is allowing the truss to pick-up extra moisture from the ground or by exposure to the elements. This moisture will come back out after the truss is enclosed in the structure. There will be more movement taking place after the truss is installed than there would if it had been kept dry.

### ○ Settlement

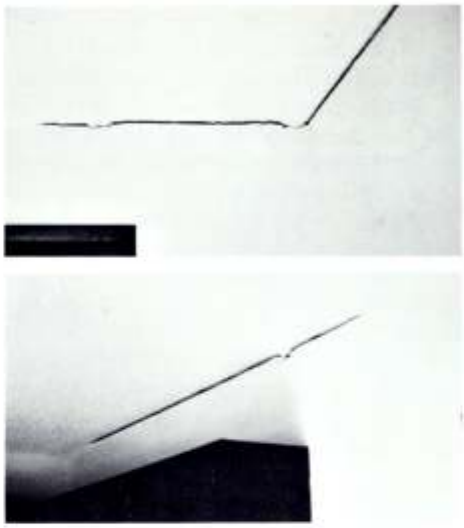
Downward movement of the supports in any type of structure can lead to CFPS. Settlement of foundation walls or individual pier footings can be a result of inadequate soil strength or undersized bearing areas. Footings that are too shallow will move when the moisture in the soil freezes and thaws. In crawl-space construction, stacking of wood blocks to support and shim a beam at a pier can give the impression that the pier is settling. The load on the blocks could then compress enough to cause CFPS or even crush if the bearing surfaces are not large enough.

### ○ Construction Practices

Some construction practices can lead to cracks in drywall, or at least they can indirectly help them to happen. Forcing lumber to fit into place will cause stresses to be built into a structure that may eventually find a way to be relieved. Straightening out bowed, warped or twisted lumber will

[1] Percival, D.H. and Suddarth, S.K., 1983. "Longitudinal Moisture Response In Truss Lumber - A Potential Cause Of Ceiling-Partition Or Floor Partition Separation" Forest Products Journal 33(11/12): 19-28.

Trusses may gain moisture and swell if they are allowed to lie in water at the job site.



The ceiling-floor partition separation (CFPS) phenomenon can be seen here in the ceiling opening.

Compression wood showing unusual ring pattern and cracks across the rings.

only be temporary if the forces are large enough. Pulling the camber out of the bottom chord of a truss and then nailing it to the interior partitions is also a temporary situation. If a truss is pulled down far enough, it will eventually return to its original position. This happens when the wood around the nails holding the truss down relaxes enough for the nails to be pulled out. Nails may be able to resist the large withdrawal for a while, but not indefinitely.

Storing dimension lumber on the ground and unprotected from precipitation at the job site is a practice that will aggravate the shrinkage problems. It doesn't take very long for lumber stored this way to take on extra moisture. This moisture will cause the wood to swell, but all of this additional swelling will shrink back out when the wood redries in the completed structure.

The practice of holding the ceiling drywall fasteners 12 to 16 inches back from partition walls helps to isolate the movement that causes cracks. The wall board supports the floating edge or end of the ceiling board, but there are no fasteners to pull the ceiling away from the wall and open the joint. The ceiling board is flexible enough that it can hide much of the movement at partition walls.

### Deflections

Some movement in wood structures can be attributed to deflection. It may show up when trusses of different stiffness are placed near each other. This could be a scissors truss next to a flat bottom chord truss, or maybe a girder truss next to a common truss. In these situations, one truss could be much stiffer than the other so their deflections are different. The result might be a bulge in the ceiling or an uneven ridge line. In floor framing, some joists carry more load than others. Joists under partition walls or around stair openings are some examples of this. These joists will sag more than those with less load, and if they are under a partition wall, this could cause cracks to appear.

## FINDING THE CAUSES

Identifying the cause or causes of any particular movement in a building requires a careful and thorough investigation. It typically involves checking the basement or crawl space as well as the attic, and no part of the structure can be automatically ruled out as not being involved.

The time of year when movements occur can provide some clues to the causes. When cracks appear after a building's first heating season has begun, this suggests that wood shrinkage is involved. Cracks that continue to open up with time suggest that settlement or deflection is taking place. Cracks that open and close seasonally point to things like truss or joist arching and frost heaving.

Since no building is built perfectly plumb, level and square, these measurements don't reveal much unless there are reference points. This means recording measurements of walls, floors and ceilings at different times to see where the movement is. String, chalkline and tape measure are the most useful tools for this. The chalkline can be used to put straight lines on joists and trusses as a reference for future movement. A plain string line stretched taut against a floor or ceiling will reveal the contour of the surface. Deviations from the line can be measured at specific locations for later comparisons. Diagonal measurements of walls or wall openings may also help to locate movement.

Sometimes a moisture meter can be useful. It can at least reveal if there is enough difference in top and bottom chord moisture content for truss arching to be a possibility. It can also reveal unusually high moisture content in wood that could indicate improper or inadequate ventilation or ineffective vapor barriers.

Truss designers and truss fabricators are naturally concerned about ceiling-floor partition separations that are caused by truss arching. There should be some consolation in the fact that trusses are often the best part of a building's structure in terms of the grade of materials, the quality of workmanship, the control of moisture content and the engineering that goes into them. Also, only 25 percent of the CFPS cases in the Percival and Suddarth survey were reported to reoccur annually. This suggests that truss arching was not the major factor in the majority of cases. Just remember that there are often several factors involved in any particular case of CFPS, and that proving a truss has arched is often just as difficult as proving it has not.