Research Report

Gypsum Joint Ridging and Cracking

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Structural Building Components Association (SBCA)

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Introduction:

Consider the following scenario: You have just finished construction on your new home. It was a long, difficult winter and you spent countless hours working with the general contractor on this project. He came highly recommended and you have been very happy with his performance and that of his subcontractors. It is finally time to move into your new home and enjoy the fruits of those labors. Winter gave way to spring and summer and you noticed a crack appear in the joint between two gypsum panels in your great room. Two years and several repairs later, the crack continues to appear each summer. Your relationship with the builder has become strained and the finger pointing has begun. The drywall installer insists that it was a problem with the framing; the framer insists it was the drywall installer or maybe it was the trusses that were faulty. How can this issue be resolved, and what can be done to prevent this from happening on future projects?

Background:

Cracks in the center of taped drywall joints that run perpendicular to floor or roof trusses are a common problem in homes. These cracks are characterized by their appearance in the center of taped joints running parallel to tapered edges or factory seams. They are primarily observed in areas that span large open spaces. The cracks may actually tear the drywall tape and may continue to grow over time. Furthermore, the width of a crack may vary cyclically as the seasons change.

Ridging is the opposite phenomenon that typically occurs on a taped gypsum board joint running perpendicular to floor or roof trusses. Ridging is characterized by the appearance of a small hump approximately $^3/_8$-inch wide, usually running along the taped joint of ceilings that span large open areas. The Gypsum Association defines ridging in the following way in its publication *Repair of Gypsum Board Joint Ridging* (*GA-221-14*):

> Joint ridging, also called beading, is a uniform, fine linear deformation occurring at gypsum panel product joints. It is usually caused by compression of the edges or ends of the finished and decorated gypsum panel products. This compression is the result of the edges or ends being forced together from exposure to alternating periods of high and low temperature and humidity extremes.

Sometimes, both of these issues appear at the same location, with cracking appearing in wetter months and ridging in drier months. This problem has become more widespread as homeowners insist on larger rooms and open floor plans that have large clear span areas.

Local environment seems to play a significant role in every gypsum ridging and cracking (GRC) case of which SBCA is aware. All reported cases of GRC have been in dry areas of the country, where humidity changes are the most drastic from season to season. Arid regions of Australia and New Zealand have reported similar cases of GRC.

Lumber and drywall expand and contract with changes in temperature and humidity. However, calculations show that shrinkage/expansion caused by seasonal changes in temperature and humidity is relatively small and not normally sufficient to cause GRC in standard construction. For example, according to the National Oceanic and Atmospheric Administration's National Weather Service (NOAA/NWS), in Las Vegas the average relative humidity ranges from 56 percent in January to 25 percent in June (a 31 percent seasonal change). Under normal circumstances, a change in the relative humidity of at least 50 percent over a long period of time (at least 18 days) is necessary to create a large enough differential in the expansion/contraction of building materials to produce GRC. While it is possible that this degree of relative humidity change could occur in any given year, it is not the norm.

In the late 1990s, two independent groups took on the task of researching the issue of GRC and their results were published in *Walls and Ceilings* under the title of "Drywall Cracking on a Global Scale", written by Greg Campbell in 2001. Both groups believed, due to the cyclical nature of the problem, movement of wood members was the cause. However, the reason for that movement remained a mystery. Many theories were suggested, but none had any basis in actual testing.

The first group was based in the United States and was comprised of wallboard and finishing product manufacturers, drywall contractors, truss fabricators, code officials and framing contractors, and was sponsored by the Drywall Finishing Council. The group focused on drywall cracking problems in southern California and Las Vegas. In order to collect data during testing, an electronic monitoring system was installed in two Las Vegas homes.

The second group, a joint effort by the Drywall Association of Nevada and Monash University in Melbourne, Australia led by Dr. Bob Milner, constructed a 20-meter square structure consisting of a framed wall, ceiling and roof structure within a climate controlled chamber. They put the building assembly through a variety of tests and were successful in recreating the GRC problem repeatedly.

Both teams were in search for the cause of GRC, and came to similar conclusions that we can draw upon to understand this phenomenon better.

Analysis:

Drywall Association of Nevada and Monash University in Melbourne

Building material dimensions change as their moisture content fluctuates. The moisture content of drywall and lumber in residences that were constructed during the summer months, and subjected to the increased humidity during the winter, was observed to increase. This increase in moisture content caused all of the construction materials observed to expand; however, the framing lumber increased in length to a much greater degree than did the drywall. When the drywall was secured to wood, the differential increase in dimension caused tension to occur in the drywall, which literally pulled the drywall tape joints apart.

The observed effects were visually reversible and repeatable. When the same structural system discussed above was constructed during the more humid winter and spring seasons, and passed through the dry summer months, the materials were observed to shrink. Since the lumber reduced in length to a much greater degree than did the drywall, compression occurred in the drywall, which produced ridging at the tape joint.

Greater humidity extremes caused greater observed problems. The tests found that the greater the seasonal humidity swing (i.e., summer-to-winter or winter-to-summer), the worse the cracking and ridging problems became.

Temperature fluctuations were found to play little role. While summer-to-winter temperature fluctuations played some role in the movement (primarily in the drywall), the effect was generally immediate (within 24 to 36 hours after initially conditioning the home) and small (less than 20 percent of the overall movement required to generate a tape joint crack was caused by temperature).

While the use of kiln-dried lumber in trusses produced some benefits, it did not ensure that cracking and ridging would be prevented. Conditioning homes for 24 hours prior to installing board reduced cracking by nearly 20 percent. Resilient channels proved to be the most efficient in preventing GRC. Ceiling construction utilizing resilient channels between the drywall and the framing seemed to produce the most consistent reduction in incidents of tape joint cracking and ridging, even when past repairs failed.

Fortunately, expansion or contraction does not occur every time humidity shifts. Both U.S. and Australian/New Zealand groups noted that humidity levels must change by at least 50 percent and be maintained for a prolonged period of time. The Australian research team was able to introduce cracks in its test assembly by changing the humidity of the climate chamber from 20 to 90 percent, maintaining the higher level for 18 days. Similarly, the U.S. group’s electronic monitoring of Las Vegas homes found that a change of 50 percent in relative humidity lasting for at least 30 days was needed to cause a significant change in the moisture content of framing members, resulting in dimensional movement.

Framing Issues

While the research of the Drywall Association of Nevada and Monash University in Melbourne concluded that temperature and humidity changes are likely the most significant cause of GRC due to the differential in properties of materials used as substrate for gypsum wallboard, care must still be taken to mitigate the severity of the issue. This can be done by framing the structure in a way that lessens the magnitude of material movement due to poor framing practices. The following are some of the items that can allow material movement after gypsum products have been installed:

- Use of unseasoned (wet) lumber (which is common in some parts of the country) may be a significant factor in ceiling cracking, particularly when the ceiling is installed before the moisture level of the lumber has been reduced to a reasonable level.
- Misaligned studs and headers around doors and windows. Joints need to fit tightly and have no gaps between the jack studs and the headers. Likewise, headers need to be tight against the top plate of the wall or the cripple studs above the header.
- Gaps between wall top plates due to improper attachment.
- Gaps between studs and plates.

- Studs that vary in length, causing uneven plates and gaps.
- Long walls or ceilings with no breaks: due to expansion and contraction, this area can result in cracks or ridges in seams.
- Crooked framing: often not noticed until drywall is being attached or taped, or trim is being attached.
- Poor insulation job: a poor insulation job can make drywall difficult to attach. Overstuffing of wall cavities or improper attachment of insulation can lead to excessive stresses in the gypsum joints.

The Gypsum Construction Handbook, by the USG Corporation, Chapter 2 – Framing, states the following in regard to framing and allowable deflection criteria.

- **Loads**: Framing members and their installation must be selected according to their ability to withstand the loads to which they will be subjected. These include live loads (contributed by the occupancy and elements such as wind, snow and earthquake) and dead loads (weight of the structure itself). Minimum lateral load for interior partitions is 5 psf; for exterior walls 15 psf to 45 psf or greater depending on building height and geographic location.
- **Deflection**: Even though an assembly is structurally capable of withstanding a given load, its use may be restricted if the amount of deflection that would occur when the lateral load is applied exceeds that which the surfacing materials can sustain without damage. Obviously, this deflection factor influences the selection of surfacing materials.

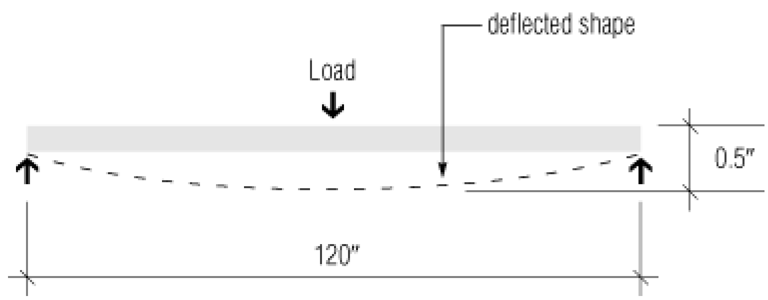
  For drywall assemblies it is desirable to limit deflection to L/240 (L = length of the span in inches) and to never exceed L/120 (L/180 in some codes). The preferred limit for veneer assemblies is L/360 and should not exceed L/240. Using L/240 as an example, and where the length of a span (distance between framing members) is 10′, deflection is determined as follows:

$$\text{D = Deflection Limit} = \frac{L}{240}$$

$$L = 10' \text{ or } 120''$$

$$D = \frac{120}{240}$$

$$D = 0.5''$$



Gypsum Board Installation Issues
The Gypsum Association has recognized that difficulties can arise from the improper installation of gypsum products, especially when installation takes place in cold or wet conditions. As a result, the association has published *Gypsum Board Winter Related Installation Recommendations (GA-220-06)*, in which the following is stated:

Cold and damp weather conditions can contribute to joint compound bond failure, delayed shrinkage, beading, nail popping, joint shadowing and board sagging. Observing the following precautions during periods of cold and damp weather will reduce job problems.

- Gypsum board and joint treatment should not be applied to cold or damp surfaces.
- For mechanical installation of gypsum board, room temperature should be maintained at not less than 40°F (5°C), and not less than 50°F (10°C) for adhesive application of gypsum board and for joint treatment, texturing and decoration.
- Interior temperatures should be maintained at not less than 50°F (10°C) for a minimum of 48 hours and the gypsum board should be completely dry before taping and finishing. Subsequent finishing and texturing should not proceed until previous applications are completely dry. Ready-mixed joint compounds and textures shall be protected against freezing in storage.
- Where materials are being mixed and used for joint treatment or the laminating of one layer of board to another, the temperature of the building should be maintained at not less than 50°F (10°C) for 48 hours before and continuously until applied materials are thoroughly dry.
- When a temporary heat source is used, the temperature should not exceed 95°F (35°C) in any given room or area.
- Ventilation shall be provided to ensure normal drying conditions. (Note: Gas-fired heaters generate considerable quantities of water. The use of gas-fired temporary heat equipment may result in unusually high humidity conditions.)
- The use of setting type joint compounds can help avoid many cold weather related finishing problems.
- A latex primer should be applied and allowed to dry before decorating. This often takes between 36 and 48 hours when the weather is cool or damp.
- The proper thicknesses and types of gypsum board should be used to avoid sagging when ceilings are to be textured.
- Where a vapor retarder is required, it is suggested that foil backed gypsum board or vapor retarder faced mineral or glass fiber insulation batts be used.
- When a polyethylene vapor retarder film is installed on ceilings behind the gypsum board, it is important to install the batt or blanket ceiling insulation BEFORE the gypsum board; when loose fill insulation is used, install the insulation IMMEDIATELY after the gypsum board.

Additional Resources
The Gypsum Association (www.gypsum.org) and the Drywall Finishing Council (www.dwfc.org) provides these recommendations on drywall installation:

- Gypsum board must be maintained at a minimum temperature of 50°F and be dry for at least 48 hours prior to the application of drywall joint compounds, textures, and paints or coatings.
- Gypsum board must be thoroughly dry and at ambient temperature before application.
- The relative humidity within the structure must be controlled before, during and after gypsum board application.

- Provide extra ventilation for any activities that create high humidity after the gypsum board application, such as the pouring of concrete basement floors.

- In cold weather, inside temperature shall be maintained between 50°F and 70°F. When portable heaters are used, the extra humidity that they produce must be removed.

- Concrete surfaces must be aged at least 60 days prior to the application of drywall joint compounds, drywall textures, paints or coatings.

- Drywall attachment must always proceed from the center of the panel to the ends and edges. Drywall must not be attached at the corners first and then left to hang prior to the field being attached.

- A control joint or intermediate blocking must be installed where framing members change direction.

- Control joints in interior ceilings without perimeter relief must be installed so that linear dimensions do not exceed 30 ft. and total area between control joints do not exceed 900 sq. ft.

- Special attention to the use and placement of control joints and maintaining recommended environmental conditions before, during, and after application are all important factors in minimizing the effects of extreme weather conditions.

- Failure to observe these requirements, particularly in areas with extreme weather conditions, will virtually guarantee finish performance problems.

For more information on these practices, refer to the following documents:

- Interior Drywall Specifications, Drywall Finishing Council
- *Recommended Levels of Gypsum Board Finish GA-214-10e*, Gypsum Association
- *Application and Finishing of Gypsum Board GA-216-00*, Gypsum Association
- *Repair of Gypsum Board Joint Ridging GA-221-14*, Gypsum Association
- *Joint Treatment under Extreme Weather Conditions GA-236-13*, Gypsum Association
- *Control Joints for Fire Resistance Rated Systems, GA-234-08*, Gypsum Association

Findings:

Based on the known facts, the results of field experience, testing and the research described above, the incidents of GRC can be drastically reduced if care is taken to reduce or eliminate those causes of GRC that can be controlled. As noted, differential expansion and shrinkage of various building materials contribute to GRC. However, this cannot be the only cause because seasonal environmental changes in the U.S. are generally not significant enough to alone produce the amount of expansion/shrinkage necessary to cause GRC. Improper gypsum installation techniques, poor framing practices and settling of a building also contribute to the problem. Since we cannot efficiently control the temperature/humidity of attic spaces beyond using proper ventilation techniques, GRC must be controlled through the construction practices that we *can* control.

Gypsum ridging and cracking problems occur most often due to improper drywall storage, handling and installation practices. The following measures should be taken to reduce the problems with GRC:

- Verify that the truss design deflection and the building designer's deflection specification (if any) are compatible or within plus or minus 10 percent of one another.

- Verify that the truss design deflection meets the USG specification as stated in The Gypsum Construction Handbook, Chapter 2-Framing, as follows:

  - For drywall assemblies it is desirable to limit deflection to L/240 (L = length of the span in inches) and to never exceed L/120 (L/180 in some codes). The preferred limit for veneer assemblies is L/360 and should not exceed L/240.

- Verify that the trusses are level and the ceiling plane is flat by measuring at various locations using a laser level.

  - Gypsum installation should occur only after the framing techniques are of sufficient quality to avoid unacceptable movement in the framing members.

- Out of level movement can be due to:
    - Concrete slabs not being level.
    - Bearing walls top plates being at differing heights along the bearing length.
    - Trusses sitting between studs causing local deformation.
- If the trusses are not level, it strongly recommended to **NOT** attempt to stiffen and/or alter trusses without the approval of the building designer and modification details provided by the building designer, truss designer or truss manufacturer.
    - Improper modification of the trusses can alter the truss system behavior and in most cases will not solve the problem.

- The drywall contractor should document the following items, as stated in the USG Gypsum Construction Handbook, regarding drywall installation. This will help all parties understand the circumstances leading up to the gypsum installation should an instance of GRC occur.
    - Date, time, temperature and humidity at the time of drywall application.
    - Method and how long the structure was conditioned prior to installation.
    - If ventilated, the method of ventilation. (Contractor should provide this).
    - The type of joint compounds used.
    - The type of finish specified and what was implemented.
- Allow materials to condition at the site prior to installation.
- Allow materials to condition for 48 hours prior to the joint taping process.
- Use resilient channels.
    - Ceiling construction utilizing resilient channels between the drywall and the framing produced the most consistent reduction in the incidence of GRC even when past repairs failed.
- Back-block gypsum board joints.
    - This is an additional cost, but it is cheaper than call backs and dissatisfied customers.
- Prior to installation, inspect the framing to eliminate, as much as possible, gaps between framing members that will affect the wall board installation process.
- Avoid use of wet lumber.
- Use control joints (Figure 1) in long walls and ceilings.
    - Control joints in interior ceilings without perimeter relief must be installed so that linear dimensions do not exceed 30 ft. and total area between control joints does not exceed 900 sq. ft.

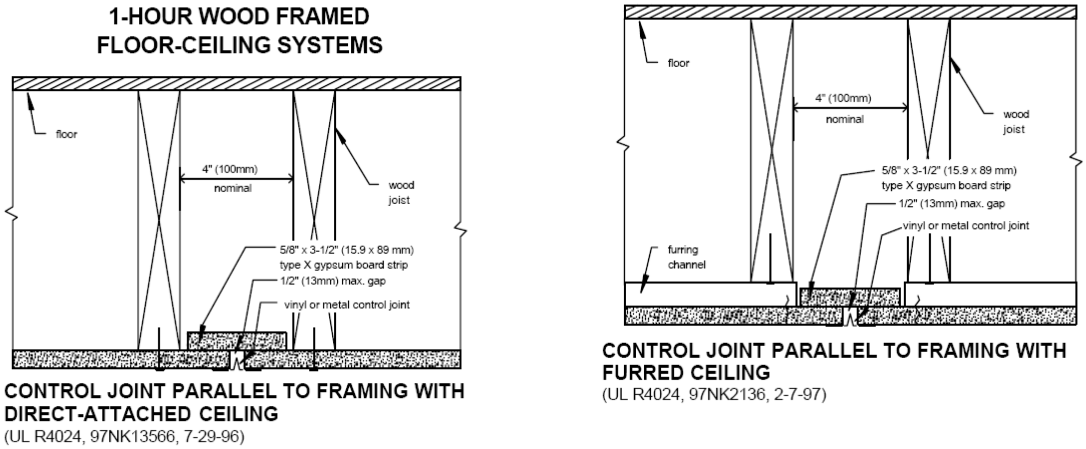


Figure 1: Control Joints

Conclusion:

An understanding of what causes GRC will help all involved parties to work together on a project, and produce an end result that everyone is proud of—and that minimizes owner call backs. Many of the problems associated with GRC can be avoided if the proper precautions are observed. Both the Gypsum Association and the Drywall Finishing Council provide excellent resources explaining the proper methods that should be used.

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