# Getting a grip on greens firmness

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**Bottom line: Greens firmness is a complex problem, starting with the challenge of measuring it and finding a definition that everyone can agree on. In preliminary work on greens firmness, we have identified two useful tools for quantifying and defining guidelines for greens firmness — the Clegg Impact Soil Tester, which measures soil strength, and the Spectrum TDR300 Soil Moisture Meter. Greens that are firm have been measuring 70 to 125 gravities on the Clegg, and between 15% and 25% on the soil moisture meter. During 2006, we will test these guidelines in a variety of locations and turf types and will adjust as necessary. This information will then be used identify management practices that will promote greens firmness without threatening turf quality and health.**

Earlier this year, we teamed up with David Zahrte, CGCS of Santa Ana Country Club (Santa Ana, CA) to begin to identify the factors that can provide us with more control over greens firmness. This research project, which will be conducted over the course of 2006, asks the following questions:

- Which factors contribute to greens firmness?
- Which tools can be used to quantify greens firmness?
- How can optimal levels of greens firmness be identified?
- Which management practices will help to achieve more consistent greens firmness throughout the year?

By monitoring soil moisture, turf quality and surface firmness parameters throughout the year, this study hopes to identify irrigation and other practices that can combine that sometimes contradictory demands of keeping the turf quality high while at the same time achieving the optimal firmness for golf play.

In this issue of *PACE Insights,* we will summarize our preliminary findings on this topic. We will follow up with a final report later this year.

## A little background

The golfer controversy over greens trueness and firmness has been ongoing for many years. The following quote from the May 1947 United States Golf Association's "Timely Turf Topics" illustrates the persistent focus on firm and true greens:

> *Putting surfaces should be firm to avoid foot printing and should be resilient so that a properly-played shot will hold, but should be sufficiently solid so that a poorly-played shot will roll over. The surface should be smooth and true as a billiard table. Density of the turf should be so great that individual grass blades are crowded to a true vertical position. "Graininess," "sponge" or "mat" destroy the accuracy and Fun in golf. Governing factors include: choice of grass, soil texture, drainage and aeration, fertility level, and watering practices.*

Not much has changed in the desire of golfers for a firm and true greens surfaces since 1947. Despite this, methods for addressing the problem have not been extensively researched and documented. This is partly because the nature of the problem varies widely from one golf course and one group of golfer's perceptions to another. It is also because the management practices that are required to improve firmness frequently require long-term overhauls of the greens.

**Figure 1. Quantifying greens firmness with the Clegg Impact Soil Tester**. The 5 lb hammer is lifted to a height of 18 inches (a) and dropped (b). The hammer contains a sensitive decelerometer that measures the speed of deceleration upon impact with the greens surface. The higher the impact that is recorded on the digital readout (c), the firmer the green surface. The procedure creates a 2 inch wide circular dent in the greens surface (d), but recovery is rapid.


## Improving greens firmness: where to start?

As with many agronomic issues on the golf course, there are both long-term and short-term approaches for improving greens firmness. While long term efforts are usually required to produce significant and sustainable improvements in greens firmness, they usually require major investment and overhauls. Short-term fixes, on the other hand, are easier to implement, but may provide less dramatic and more temporary results.

**Long term fixes:** For most golf courses, the governing factors that will influence firmness are the same as those listed in the quote above. Unfortunately, major re-construction is required to modify the factors most directly implicated in greens firmness, which include:

- the nature of the root zone sand
- the turfgrass variety (for example, bentgrass provides a firmer surface than poa)
- improved drainage

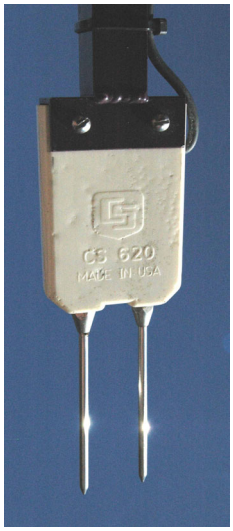
Without these major changes, greens firmness cannot be fully maximized.

**Short term fixes:** There are, however, several less dramatic management practices that can lead to some improvements in greens firmness. These include modifications in aeration/topdressing procedures and watering practices.

## Short-term fix 1: aeration and topdressing

An increased frequency of aeration, followed by sand topdressing, will lead to firmer greens. Frequent light topdressing will further improve firmness. This occurs because topdressing results in the dilution of the softer organic matter (thatch and mat) present on the green with sand. The compromise is that the trueness of the surface will be impacted for about 14 days following each aeration event. New, smaller diameter aeration tines may improve recovery and allow more frequent aeration to increase firmness. Even if increased aeration cannot be tolerated, application of sand as topdressing without aeration is a practice that might be evaluated to increase the firmness of the greens during the summer. See page 4 for some suggestions on procedures.

**Figure 2. Spectrum TDR 300 soil moisture probe**. For cool-season turf on sand-based greens, we generally target a range of roughly 15% – 25% volumetric water content for optimal turf growth and optimal firmness. A close-up of the probes that are inserted into the soil appears to the right.




## Short-term fix 2: watering practices

A second, more controversial approach to improving greens firmness involves modified watering practices. This is the focus of our current research, because we think that it is here that some real improvements in firmness can potentially be made. Our position is based on these key assumptions, some of which may seem obvious to you, some of which may not:

1. The wetter the soil, the softer the soil surface.
2. Greens are never irrigated uniformly. No matter how expensive and how sophisticated your system is, today's state-of-the-art in irrigation still produces some areas that are over-watered and other areas that are underwatered (see Figure 4). Until golf course designers and irrigation designers work together more creatively, we will be forced to deal with the unpleasant reality of poor irrigation distribution.
3. Lack of irrigation uniformity leads to varying levels of soil moisture — and varying levels of firmness — across the green.
4. If the root zone mixture and drainage are optimal, then non-uniform firmness problems that stem from non-uniform irrigation can be minimized. This is because good drainage allows you to overwater some areas (in order to avoid underwatering other areas), with minimal impact. The extra water will quickly move through the profile, having little effect on surface firmness. But, if drainage is poor, water will stay in the upper profile and will decrease firmness. The recommendation above for more aggressive aeration and topdressing programs will help to slowly and gradually address water movement problems. But it will not improve underlying drainage problems — that has to be handled separately.
5. Hand watering is the best short-term solution to the problems caused by non-uniform irrigation of greens. However, more precise indicators of when, where and how much to water are required for optimal and homogenous greens firmness.

## Defining optimal firmness

For the most part, greens firmness on golf courses has been measured only subjectively in terms of the "feel" of the surface underfoot, or to general evaluations on the severity of ball marking, or the lack of ball bounce and roll. While these subjective measures have value, they are usually particular to an individual (what one person may describe as "too soft" may be perfect for another) and not easy to measure in a reproducible way. With only subjective measures as a guide, it is difficult — if not impossible — for turf managers to determine the current status of greens firmness or to measure the way in which management practices increase or decrease firmness.

It is for this reason that we seek out tools that can provide objective measurements of firmness. Ideally, these would be used in concert with subjective measurements to form as complete an evaluation as possible of greens conditions.

After reviewing the literature and communicating with researchers and turf managers, we believe that we have located a tool that will be of assistance. It is known as the Clegg Impact Soil Tester (Clegg; see Figure 1). This tool (available from Lafayette Instruments, www.lafayetteinstrument.com/clegg.htm; $2,500) is widely used for measuring surface firmness on sports turf and has more recently been picked up by turf researchers in New Zealand and the U.K. Its cost makes it useful primarily as a research tool at this point; however, part of our study at Santa Ana CC will evaluate the use of the Clegg for assessing greens firmness there. If it can provide good quantification of greens firmness, it may be worth the investment

The Clegg operates by measuring the impact of a 5 lb hammer when it is dropped from a height of 18 inches. The hammer contains a sensitive decelerometer that measures the speed of deceleration upon impact with the greens surface. The higher the impact recorded on the digital readout, the firmer the green surface.

## A preliminary guideline

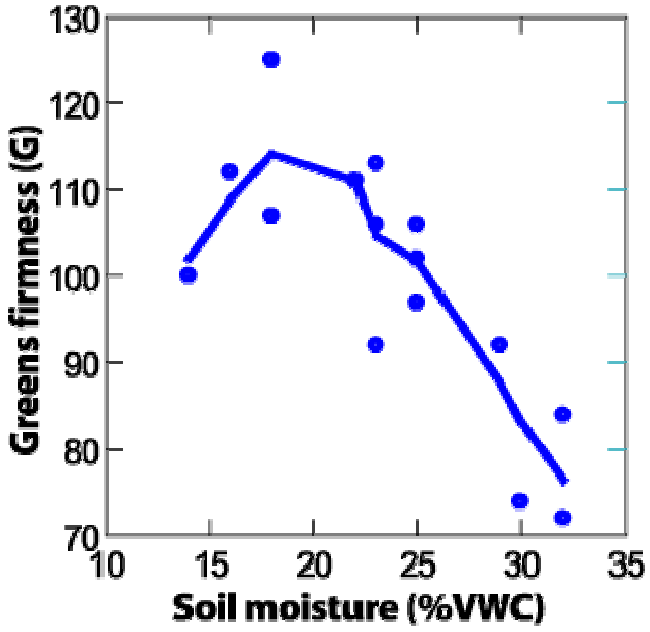
Researchers working on golf courses in Britain (Baker et. al. 1996) and New Zealand (Linde, 2005) have identified Clegg readings that produce desirable levels of greens firmness. Baker used simulated golf ball launchers that mimicked the impact of a ball hitting a green with the impact that might be typical for a 5 iron (53 degree impact angle, velocity of 22.7 m/s, backspin 750 rad/s) and a 9 iron (53 degree impact angle, velocity 18.8 m/s, backspin 880 rad/sec). The unique research equipment he used for this study is not available for general use, but fortunately, Baker found that there was a significant correlation between firmness evaluated using the ball impact simulators and the Clegg. Based upon their fairly extensive surveys of golf courses in Britain, a range of Clegg measurements between 70 – 120 g (gravities) was considered to result in good ball bounce and roll. In a similar study conducted in New Zealand, Linde found that greens reporting Clegg values of less than 50 g were too soft and greens that reported Clegg values of more than 140 g were too hard. The average for high-end golf courses in New Zealand ranged between 78 and 122 g.

Based on this work, we have identified Clegg readings from **70g to 125g** as an optimal range for cool season greens. Below this value, and greens are likely to be too soft. Above this value, they will be too hard. At this point, this range of values applies only to cool season greens. Our research will expand to include readings on bermudagrass greens as well, in the near future.

One of the goals of our work at Santa Ana CC is to make sure that these values match up with superintendent and golfer input on greens firmness. So far, we are seeing a good agreement (see below), but we will modify this target range if necessary as research progresses.

The Clegg values observed at Santa Ana CC during our initial visit in January, 2006, ranged between 62 and 125g — almost completely within the 70 – 125 g guideline that we had set. Golfer's positive evaluations on firmness, obtained on the same date, confirm this conclusion. It is expected that as hot weather and increased irrigation demands occur during the summer months, firmness may decline. It is during the warmer months that the most difficult challenge in terms of maintaining green firmness while maintaining turf health occurs.

**Figure 3. Relationship between soil moisture and green firmness. (Poa annua green).** Note that firmness drops when soil moisture levels increase above 25%. Firmness was measured using data from the fourth and final drop of the Clegg Impact Soil Tester (Figure 1) and measured in "g"s (gravities). Soil moisture was measured as % volumetric water content (VWC) with the Spectrum TDR 300 soil moisture probe using 4.8 inch probes (see Figure 2). Four locations on four different greens were sampled, for a total of 16 data points.




## Greens firmness vs. soil moisture: is there a connection?

Yes, there most definitely is. When we measured soil moisture levels at Santa Ana CC during our January visit and compared them to Clegg firmness readings from the same areas, the connection was very clear (Figure 3). The tools we used to do this were the Clegg and the Spectrum TDR 300 Soil Moisture Probe (available from Spectrum Technologies (www.specmeters.com; $1195.00).

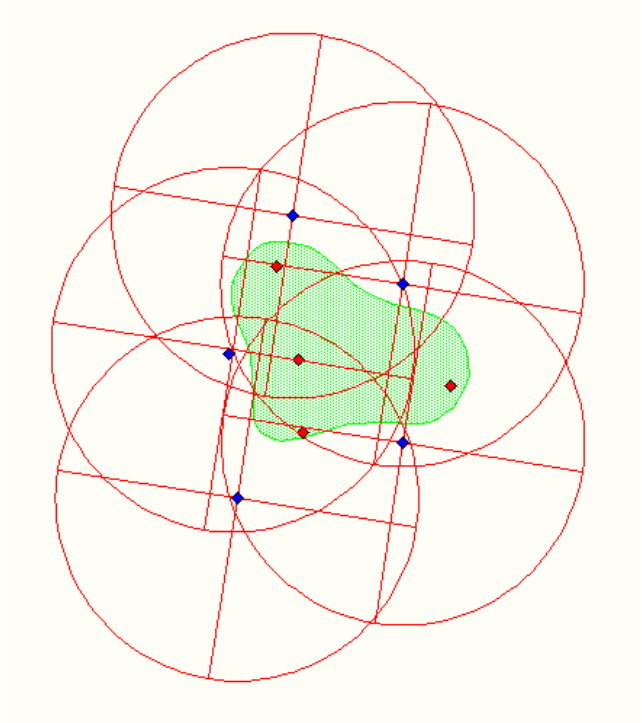
For sand-based greens, we generally target a range of roughly 15% – 25% for optimal turf growth and optimal firmness. Although moisture levels below 15% produce good firmness, turf health may be seriously compromised. And soil moisture levels above 25% produce softer surfaces.

## The role of irrigation in greens firmness

A further challenge with regards to managing soil moisture relates to the inherent flaws in today's irrigation system designs. Compounded by the irregular shape of greens, it is unfortunately the case that portions of the same green are typically irrigated from anywhere between two to five

different irrigation heads (Figure 4). This results in uneven application of water, uneven soil moisture levels and varying levels of firmness. To compensate for these design flaws, the superintendent must combine a series of tactics, including targeted hand watering (to areas that receive too little water), irrigation system adjustments (micro-management of irrigation head run cycles) and constant adjustment and re-adjustment of the system.

**Figure 4. Irrigation distribution issues.** Irrigation coverage ranges from 2 to 5 heads on this green, depending on the location. The blue dots illustrate the location of irrigation heads. The red circles illustrate the 67 ft throw of each irrigation head. The red dots illustrate the location of each soil moisture and Clegg reading.



## Mastering the balancing act between turf health and greens firmness

Reducing irrigation levels to increase firmness carries with it a great risk. Once the soil has dried to a level that exceeds the ability of the turf plant to extract water, the plants will wilt and die and a minimum of 6 weeks of conducive weather conditions will be needed before the return of acceptable putting conditions. In the peak heat of the summer, this period of time will be longer and if traffic is allowed on the damaged areas, the time to recovery will be extended even further.

Now that we have illustrated your dilemma — that irrigation distribution on greens is poor, that this problem produces variable firmness levels on greens, and that soil moisture management carries with it great risks to turf health — what can be done? Is it possible to reduce and/or better manage irrigation or hand watering, especially during the summertime, while at the same time maintaining healthy turf? We believe that the answer to these questions is “yes”, but that reliable firmness and soil moisture guidelines must be identified in order to convert this idea into practice.

## Beginning steps towards improving greens firmness

We will keep you updated on our progress and any new practices that we identify. Until then, some or all of the following practices will assist you in improving your greens firmness.

- Target soil moisture between 15 and 25% using a Spectrum TDR300 using 4.8 inch probes. The $1195.00 price tag is hefty, but if you have greens firmness issues, this can be a very useful tool.
- Address irrigation non-uniformity by adjustments to the irrigation system and by utilizing hand watering if necessary.
- In the spring, aerify with 3/8” tines (2” X 2” spacing) and fill the holes with sand (for example, Caltega 7 USGA Specification sand.)*
- Lightly topdress weekly using a #30 sand applied at approximately 50 lbs/green (1 bag dry sand) using a Scotts or similar rotary spreader. Nighttime irrigation will move the sand into the upper thatch layer. This light application of top dressing sand will help modify the thatch and mat layer and firm them up, without causing damage to mowers.
- During the irrigation season, implement a monthly surfactant application (for example, Aqueduct at 4 oz/1000 sq ft) to improve water movement through the soil profile to drain.
- Prepare golfers and managers to expect some decrease in firmness during the summer. In these hot months, turf quality and health and sufficient soil moisture must be the priority because heat and/or drought induced damage is too difficult to recover from. As a result, greens may be softer than is optimal, but at least the turf will be alive!

*A more aggressive aerification program can be substituted if some disruption of optimal golf play can be tolerated in order to achieve more dramatic results. This relies on springtime aerification with 5/8” hollow tines and collection of plugs. Sand is then applied to a 1/4” depth. The green is then vertidrained using 3/4” solid tines, the sand is swept into the holes and all holes are filled to the top. This process will aid in firming the entire root zone but it will require a repeat of the process for at least three years before it can be terminated. This aggressive program will disrupt the trueness of the greens for an extended period of time and may trigger more rapid turf growth in the aeration holes that will result in a slightly bumpy surface. This negative impact can be partially managed using Primo and increased fertility.

## References

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Linde, D. 2005. Assessing golf course conditions in New Zealand. Golf Course Management