Executive Summary

Assessment of Testing Methods for Surface Bearing Strength of Golf Course Putting Greens

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The initial phase of this project has focused on the development, and refinement, of quantitative tests to assess surface quality and the physical characteristics of putting surfaces associated with bearing strength. The project has also attempted to quantify the disruption of playing surface quality through the use of a micro-reliefmeter and measurement of the deflection of ball roll.

Micro-relief measurements are made using a depth micrometer or dial gauge. The system mounts these tools on a aluminum bracket that rests on reference stands affixed to the putting surface. Surface contour (distance) measurements are made from the aluminum bracket to the playing surface. Measurement of the surface contour is taken before and after traffic; since the bracket position is stationary any change in distance can be attributed to a change in the surface contour of the green. This method has been used successfully at the Rutgers Turfgrass Research Facility, Fox Hollow Golf Club in Lakewood, CO, Metedeconk National Golf Club in Jackson, NJ, and Canoe Brook Country Club in Summit, NJ.

The second measurement of playing quality we have been developing is ball roll deflection. Currently the data for ball roll deflection is highly variable and the methodology needs refining.

Measurements at the Rutgers Turfgrass Research Facility, Fox Hollow G.C., Metedeconk National G.C., and Canoe Brook C.C. indicate that the Clegg Soil Impact Tester and Eijkelkamp 06.06 type IB hand penetrometer were adequate tools to characterize the surface hardness and soil strength, respectively, of putting greens. The emerging relationships in the data indicate that impact values greater than 70 on a putting surface result in minimal surface deformation (< 0.4-mm) after traffic with a wheelchair. Our initial ball roll deflection measurements indicate that surface deformation of less than 0.4-mm does not result in a measurable deflection of a ball roll. It should be emphasized that this is a preliminary conclusion because, as indicated earlier, a more precise measurement of ball roll deflection is needed. The higher degree of variation in the relationship between soil strength (penetrometer) and surface deformation make it difficult to confidently identify critical values at this time.

Work planned for 1996 will 1) identify the critical level(s) of bearing strength (surface hardness and soil strength) on putting greens for various forms of traffic and 2) determine if critical level(s) of bearing strength are associated with edaphic features or management practices. Testing will continue to be expanded to other golf courses located throughout New Jersey during 1996. Mr. David Oatis, Director of the Northeastern Region of the USGA Green Section, has been helpful in identifying golf courses possessing unique putting green conditions. Golf courses will be visited at least three time during the season (winter, spring, and summer). Other types of traffic to be evaluated include a single rider cart and foot traffic. We will also gather data including time of year, turfgrass species, topdressing practices and material, and texture, organic matter content and moisture content of the putting green surface.

PROGRESS REPORT

Assessment of Testing Methods for Surface Bearing Strength of Golf Course Putting Greens

OBJECTIVE: Developing test procedures for characterizing the surface bearing strength of golf greens.

The bearing strength of a putting surface determines when damage (surface deformation) from vehicular or foot traffic will occur. The initial phase of this project has involved the development, and refinement, of quantitative tests to assess surface quality and the physical characteristics of a putting surface associated with bearing strength.

OVERVIEW

Our approach to identify the critical bearing strength of a putting surface is to define the relationship between physical characteristics of a putting surface and the associated amount of surface deformation. The evaluation of a putting green surface currently includes the following:

1) Measure surface hardness and strength (impact tester and penetrometer, respectively)
2) Measure surface contour (microrelief) or ball roll resting position
3) Application of traffic (wheel chair, maintenance equipment, shoe, etc.)
4) Evaluate changes in surface contour (microrelief) or ball roll resting position (deflection).

These evaluations are being made over a wide range of putting green conditions and management practices. Results will indicate under which conditions, if any, that a particular type of traffic will diminish surface quality. The project will also identify which cultural practices are associated with "hard" or "soft" greens, thus enabling the golf course superintendent to assess and, potentially, alter management practices that influence the bearing strength of putting greens.

To date, this approach has been used at the Rutgers Turfgrass Research Facility in North Brunswick, NJ, Fox Hollow Golf Club in Lakewood, CO, Metedeconk National Golf Club in Jackson, NJ, and Canoe Brook Country Club, in Summit, NJ. At these locations, the emphasis has been placed on measuring surface hardness and strength and the change in the surface contour (microrelief) after traffic. The relationships between the change in surface contour and surface hardness and strength are developed from these data sets.

DEVELOPMENT OF METHODOLOGY

Assessing Surface Contour with a Micro-reliefmeter. Our initial version of a micro-reliefmeter was based on surface roughness, or microtopograghy, work in agriculture. This initial device was composed of a foot long wooden bracket that held a series of pins (1/16-inch diameter) vertically. The vertical pins would slide up and down within the wooden bracket as the pins were set onto a surface to "map" the contour. The repeatability of this initial micro-reliefmeter was not adequate to measure changes of approximately 1-mm (0.04-inch) in the surface contour.

Most recently, the micro-relief measurements are taken with a depth micrometer or dial gauge. The system involves mounting these depth measuring tools on a aluminum bracket that rests on reference stands affixed to the putting surface. Surface contour is determined by measuring the distance from the aluminum bracket to the playing surface. Contour measurements are taken along a transit of a putting surface that is long enough to include trafficked and non-trafficked points on the surface. The surface contour is measured before and after traffic; since the bracket position is stationary any change in distance is attributed to a change in the surface contour. Any change in the contour measurements of non-trafficked positions are recorded so that correction of measurements at trafficked positions can be made. Table 1 presents an example of the data collected for measuring the microrelief of a surface.

Data collected during the trials at the various locations indicated this technique was measuring contour at an acceptable level of accuracy. Currently, repeated measurements made on surfaces have an average standard deviation of 0.2-mm. Therefore, measurement of changes in surface contour greater than 0.2-mm are possible with this method.

Assessing the Deflection of Ball Roll. A quantitative measure of ball roll deflection would indicate the interference of ball travel caused by surface deformation. Our original approach used a stimpmeter to roll a golf ball across the line of traffic at various angles and the distance was recorded. It was apparent after numerous trials that a detailed description of the ball travel was needed. Currently, our evaluation of deflection involves measuring the resting position in a lateral as well as lengthwise (x and y) direction of travel. The data collected during these early trials does not always indicate ball roll deflection when summarized as a mean resting position. Figure 1 shows a graphical view of the ball roll data. This 'mapping' helps describe the variation in final resting position. The final resting positions before traffic were less variable than resting positions after traffic.

It should be noted that effects on ball roll were observed visually, however, the effects were not readily apparent in the data. Ball roll was not always altered and when ball roll was affected it was not altered in the same manner (the same effect on path of travel). A frequency, or number of times, at which the ball roll is altered may be one option for evaluating this data.

Quanitifying Surface Bearing Strength. The equipment evaluated for use in measuring the surface strength of putting greens were the Clegg Soil Impact Tester (2.5 kg hammer), Soiltest CL700 pocket penetrometer, and Eijkelkamp 06.06 type IB hand penetrometer. The Soiltest CL700 pocket penetrometer was not an appropriate device for this project because its range of measurement was not large enough for all putting greens conditions. Measurements at the various locations of study indicate that the Clegg Soil Impact Tester and Eijkelkamp 06.06 type IB hand penetrometer were adequate tools to characterize the surface hardness and strength, respectively, of putting green surfaces.

The Clegg Soil Impact Tester is used to assess surface hardness and impact absorption by dropping a 2.5-kg hammer in twelve different positions surrounding the area of traffic. The hand penetrometer is used to measure surface strength at twelve positions surrounding the area of traffic.

PRELIMINARY DATA AND CONCLUSIONS:

Figure 2 and 3 present the relationships between surface hardness (Clegg Soil Impact Tester) and the amount of rutting, and soil strength (Eijkelkamp 06.06 type IB hand penetrometer) and the amount of rutting caused by traffic from a wheelchair with hard rubber tires.

The emerging relationships suggest that impact values greater than 70 on a putting surface result in minimal surface deformation (< 0.4-mm) caused by wheelchair traffic. Ball roll deflection measurements indicate that surface deformation of less than 0.4-mm does not result in a measurable deflection of a ball roll. It should be emphasized that this is a preliminary conclusion because, as indicated earlier, a more precise measurement of ball roll deflection is needed.

The higher degree of variation in the relationship between soil strength (penetrometer) and surface deformation make it difficult to confidently identify critical values at this time. More data will allow us to verify the consistency of the relationship between surface hardness (impact value) and deformation, and to clearly define the relationship between soil strength (penetrometer) and deformation.

PLAN OF WORK FOR 1996

OBJECTIVES: Identify the critical level(s) of bearing strength (surface hardness and soil strength) on putting greens for various forms of traffic.

Determine if the critical level(s) of bearing strength are associated with edaphic features or management practices.

Testing of surface quality and bearing strength will be expanded to other golf courses located throughout New Jersey during 1996. Mr. David Oatis, Director of the Northeastern Region of the USGA Green Section, has been helpful in identifying golf courses possessing unique putting green conditions. Golf courses will be visited at least three time during the season (winter, spring, and summer). Other types of traffic to be evaluated include a single rider cart and foot traffic. We will also be gathering data on time of year, turfgrass species, texture, organic matter content and moisture content of the putting green surface, and topdressing practices.

The most difficult measurement of playing quality we have been attempting to develop is ball roll deflection. This method is more than measuring the length of ball roll and therefore, requires considerable accuracy in "aiming" a stimpmeter. We have constructed a mounting bracket to hold the stimpmeter in a fixed position to produce a consistently "aimed" ball roll. The use of a modified stimpmeter as described by Gaussoin et al. (1995) in HortScience will be also explored as a means to improve measurement accuracy.

Our approach will be to determine the amount of deformation that will result in an alteration of ball roll. A series of ruts with increasing depths of deformation (e.g., 0.2-, 0.5-, 1.0-, 2.0-mm, etc) will be created on various putting surfaces. The amount of rutting and the degree of ball roll defelction can then be evaluated.

Table 1. Example of microrelief measurements made on a creeping bentgrass surface at Rutgers turfgrass research facility on 20 Sep. 1995. Positions 5, 6, and 7 were measurements of traffic deformation caused by a hard rubber tire wheelchair.

	Positons along Transit								
Time Relative to Traffic	1	2	3	4	5	6	7	8	9
Before	24.49	23.7	24.45	23.78	23.81	23.85	23.59	23.76	23.71
	24.99	23.76	24.24	24.06	23.99	24.0	23.65	23.77	23.77
	24.68	24.04	24.6	23.94	24.01	23.39	23.7	23.86	23.92
Mean	24.72	23.83	24.43	23.93	23.94	23.75	23.65	23.80	23.80
Std. Dev.	0.25	0.18	0.18	0.14	0.11	0.32	0.06	0.06	0.11
After	25.0	23.71	24.62	23.92	24.73	24.68	24.13	23.82	23.91
	25.05	24.02	24.58	24.2	24.9	24.57	24.35	24.07	23.99
	24.95	24.18	24.57	24.21	25.19	25	24.18	23.89	24.08
Mean	25.0	23.97	24.59	24.11	24.94	24.75	24.22	23.93	23.99
Std. Dev.	0.05	0.24	0.03	0.16	0.23	0.22	0.12	0.13	0.19
Change of Mean (After - Before)	0.28	0.14	0.16	0.18	1.0	1.0	0.57	0.13	0.19

	Non trafficked Change	Trafficked Change
Mean	0.18	0.86

Depth of deformation is 0.68 mm for this location.

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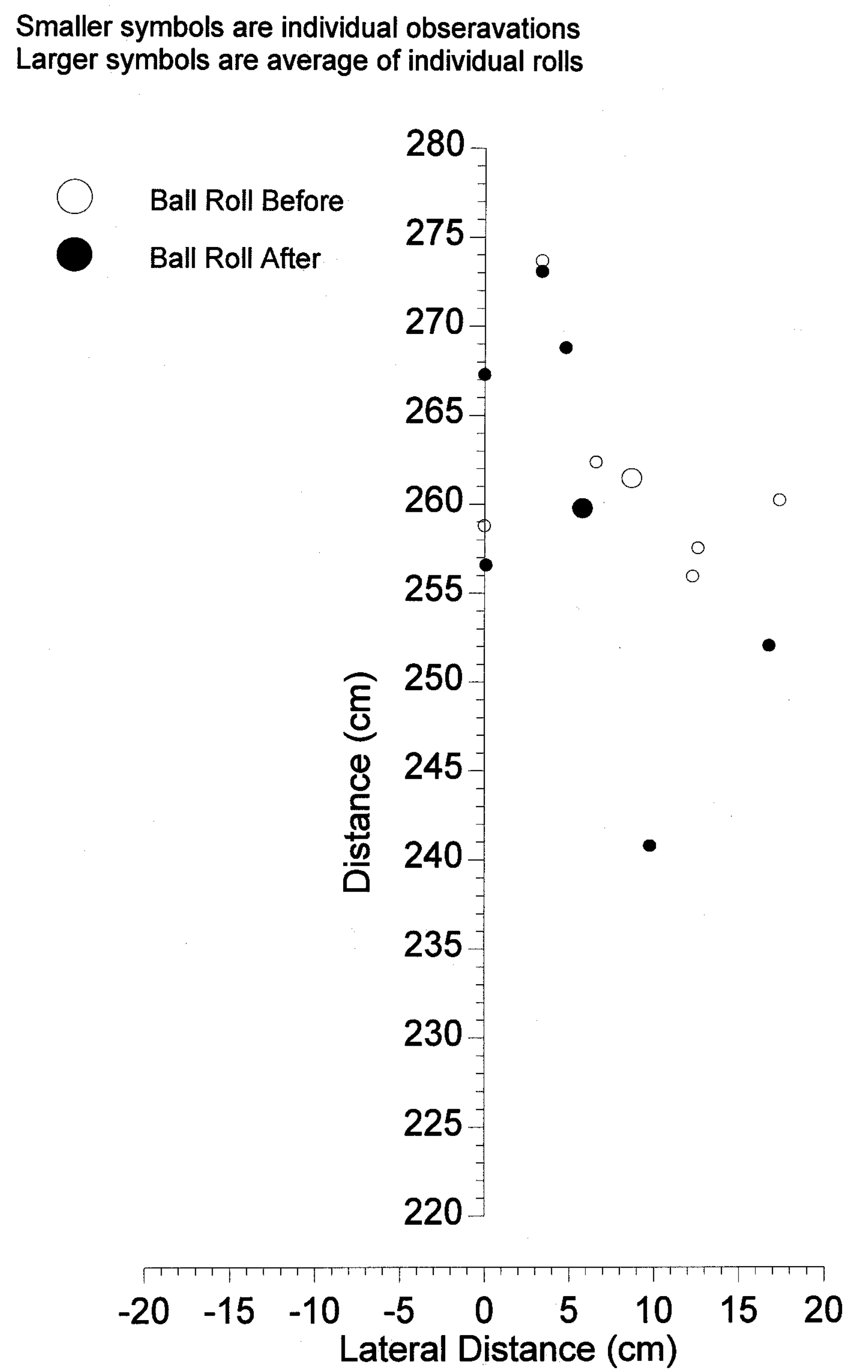

Figure 1: Ball roll data before and after traffic with a hard rubber tire wheelchair indicating final resting position. Data from 27 July 1995 for the 30 degree angle of intersect with line of traffic. Zero (0) would indicate a straight line of travel with no lateral movement during ball roll.

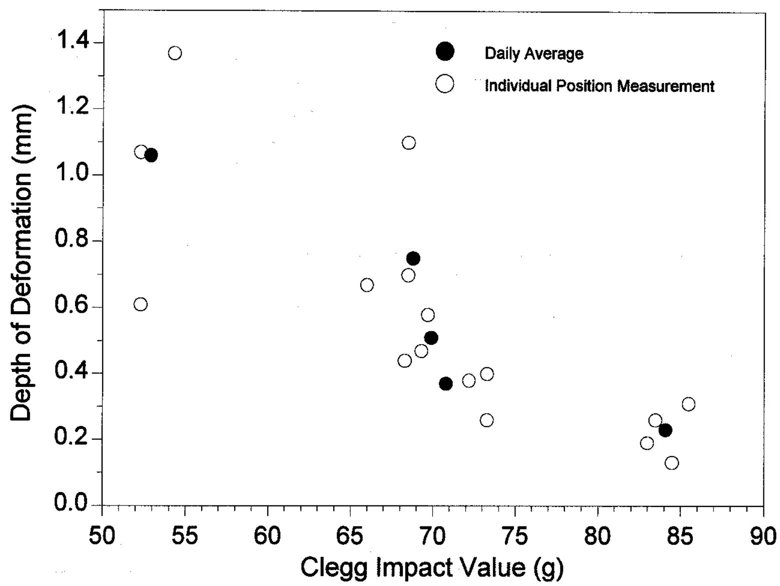

Figure 2: Preliminary relationship between depth of deformation caused by a hard rubber tire wheelchair and Clegg impact value.

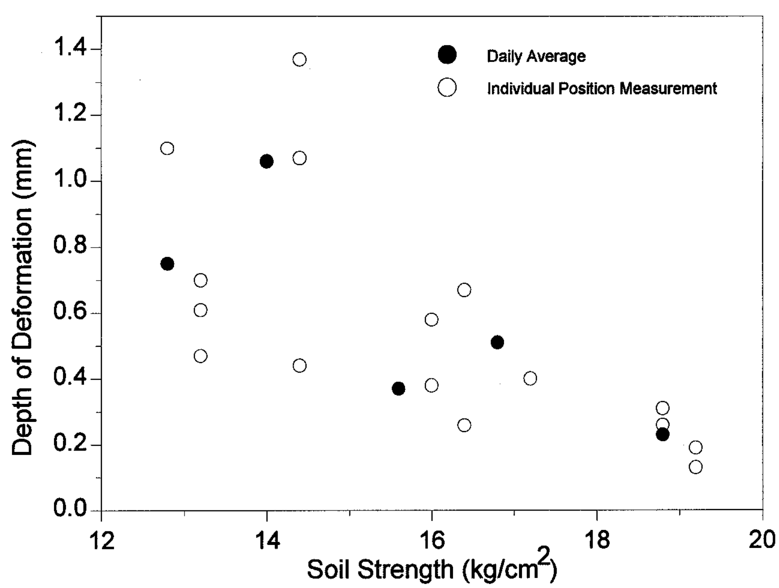

Figure 3: Prelimanary relationship between depth of deformation caused by a hard rubber tire wheelchair and soil strength (penetrometer).