The Effect of Trampling and Rolling on Turf

DR. WALTER S. HARBAN

It has always been a mooted question whether to roll or not to roll. Some hold that turf prospers better in light loamy soil, and others again as strongly advocate a moderately compact one. I must say that my experience prompts me to accept the latter view. What may be favorable for lawn turf can not be considered in turf for golf courses, as the requirements are as different as day from night. I can not conceive how a *perfect putting surface* can be developed or maintained without rolling. A certain compactness of surface apparently tends to produce a finer, denser turf; whereas in loose soil the plants are coarser and stalky. However these things may be, a golf course is designed to meet certain requirements, and the turf must withstand the hardest usage to which grass can be subjected.

Since putting greens are very severely compacted by players constantly walking over them, it would not seem unreasonable to use fairly heavy rollers at times; first, to prevent deep foot or heel prints, and secondly to smooth out those that are made when the ground is moist or soft. I can not think that many of us have appreciated how great is the load per square inch of a man's foot and what it means to a green to have several hundred players tramping on it every day and often throughout the year. The ground is necessarily much compacted, especially within a radius of five or ten feet of the hole. To present this phase of the subject more fully, Dr. Lyman J. Briggs, of the U. S. Bureau of Standards, has kindly worked out some very interesting data on the relation of weight to pressure, and which, with his consent, I take pleasure in introducing here.

Note on the Effective Load Secured in Rolling a Putting Green

DR. LYMAN J. BRIGGS

The following simple computations have been made for the purpose of forming an approximate idea of the loading to which a putting green is subjected during the process of rolling.

The limiting conditions encountered in rolling are represented diagramatically in Figures 1 and 2. Figure 1 represents a smooth cylinder roller on a hard, smooth, horizontal surface. The limiting condition in this case would be a line contact between the roller and the surface, in which case the loading would approach infinity. But, of course, such a condition is not actually realized, since both the roller and the surface deform to produce a surface of contact, and the loading falls off inversely proportional to the width of the surface of contact.

A second limiting condition is represented in Figure 2, in which the green is supposed to possess no resiliency and to be compressed as indicated in the diagram as the roller proceeds from left to right over its surface. If the green possessed no resiliency the roller would be in contact with the green only through the sector indicated by the angle a in Figure 2.

The actual conditions are more nearly represented by Figure 3, in which the green is considered to possess some resiliency and to rise up behind the roller as the latter passes over it. It is evident that under such conditions the bearing surface is greatly increased and the loading (that is, the weight of the roller divided by the projected bearing surface) is correspondingly decreased. It has been assumed in the calculations that this resiliency increases the actual bearing surface by 50 per cent over the condition as represented in Figure 2. We shall call the vertical distance from the surface of the undisturbed green to the bottom of the roller *the depth of imbedding* of the roller. Let us represent this distance by d. Let r equal the radius of the roller, and a the included angle of the arc of contact in Figure 2. Then $d = r\ (1 - \cos a)$. If s is the projected surface of contact

on a horizontal plane (Figure 2) and L is the length of the roller, we have $s = Lr \sin a$. If we assume that the loading is uniform over the projected surface of contact, the loading per square inch then will evidently be the weight w of the roller divided by s.

In the numerical computations we have assumed a roller 2 feet in diameter, weighing 150 pounds per foot-length of roller. It has also been assumed that the form of contact is that shown in Figure 3 (that is, that the projected surface of contact for any given imbedding depth is 50 per cent greater than represented by the condition shown in Figure 2). Using the equations given above and the numerical values indicated, the loading has been computed for depths of imbedding varying from 1/100 inch to 1 inch. The results are given in the following table:

RELATION OF LOAD TO IMBEDDING DEPTH

Imbedding depth	*Projected surface of contact*	*Loading pounds per square inch*
0.01 inch	8.7 sq. in.	17.2
.05	20.0	7.5
.10	28.0	5.4
.20	39.5	3.8
.30	48.0	3.1
.40	56.0	2.7
.50	62.0	2.4
.75	75.0	2.0
1.00	85.0	1.7

It will be seen from the table that the imbedding of the roller in the green to the depth of 1/100 inch results in an average load over the surface of contact of 17.2 pounds per square inch. With an imbedding depth of only 1/10 inch the average loading falls off to 5.4 pounds per square inch and decreases steadily as the depth of imbedding is increased.

When a man weighing 170 pounds supports his weight on the ball of one foot he develops a loading on the green beneath the sole of his shoe of about 13 pounds per square inch, since the area of contact of a sole of a shoe of average size is, roughly, 13 square inches. Consequently, a man walking over a green develops a much greater loading over the surface which supports his weight than would be developed by a roller of the size and weight described which settles into the green only 5/100 of an inch. It seems evident, therefore, that on a springy green which allows the roller to sink into the green to a depth of one-quarter of an inch or more, it would be necessary to employ a much heavier roller than the one used in these computations in order to secure a loading greater than that developed by the players in walking over the green. In fact, if the compression of the green is one-quarter of an inch when the player is supporting his weight on the ball of one foot, it would require a roller weighing about 550 pounds per linear foot to give an equal average loading.

Dr. Briggs does not contend that this load is equally distributed on all parts of the projected surface as indicated in Figure 3, but distinctly says, "if we assume that the loading is uniform over the projected surface." What difference this may make in his table "relation of load to imbedding depth" he has promised to work out later.

The vital points brought out by Dr. Briggs's deductions are:

First, that on a hard, smooth, horizontal surface the loading per square inch is the greatest, and as the roller sinks into the surface, increasing the surface of contact, it diminishes according to the imbedding depth.

Second, that a man weighing 170 pounds, walking over a putting green, develops a loading under the ball of his foot of 13 pounds per square inch; consequently, when the weight is carried, as it must be for a time, on the heel of the shoe, which has less than one-half the area, the load is more than doubled, as evidenced by the greater depth of heel prints when walking over soft ground.

Finally, that it will require a much heavier roller to equalize these

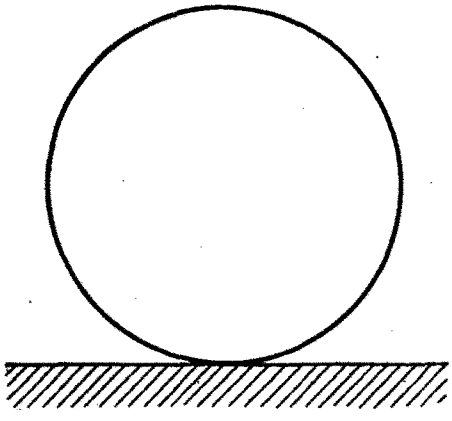

Fig. 1

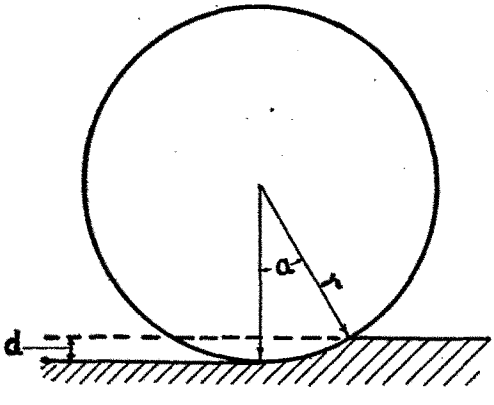

Fig. 2

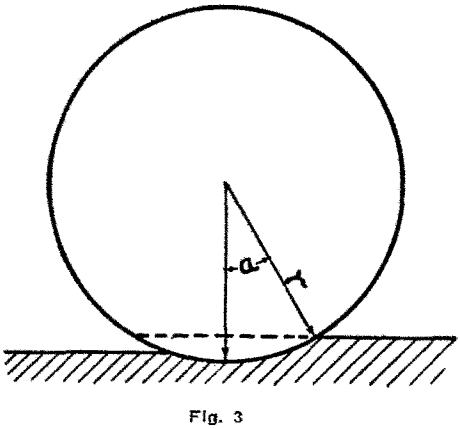

Fig. 3

differences than any greenkeeper has ever used or suggested heretofore.

I wish to emphasize what I said on page 87, Volume II, No. 3, of THE BULLETIN, as to early spring rolling, and to add that one such treatment at Columbia this spring was sufficient to put the course in good shape to prevent deep foot impressions. We shall not hesitate later to repeat the rolling if the necessity should arise. It is useless to roll when the ground is dry and hard. Wait until after a good, soaking rain, when the soil under the turf will, if tightly squeezed in the hand, crumble readily by gentle pressure of the fingers. The ground can then be rolled and will not pack or crust under these conditions, especially if covered with a fair mat of turf.

Some writers claim that rolling makes a fast course. Under some conditions this may be true. But is it not true of all courses when dried out? If you want a slow course, my advice is to pay a little more attention to the care and feeding of the fairways, as a dense turf is the greatest reducer of long driving.

I hope I have made myself clear in these observations. To sum up, I do not believe in rolling as a mere fad, but do think there are times when it is indispensable to make, keep, and protect a proper turf and surface on greens; and since they are to be compacted by trampling anyhow, I believe that, in order to meet this situation approximately at least, it is better to roll as a preventive against a greater injury.