

Golf course turf quality and maintenance management in Jinwan Golf Club of Zhuhai City, China

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Abstract. Appearance quality such as color, density, coverage, texture, mowing height and uniformity of turf in the Zhuhai Jinwan golf course were studied in the present investigation. In addition, the functional quality like elasticity, ball speed on the green and recovery ability were also studied. After evaluating the results, a maintenance protocol for the quality of the turfs of tees, fairways and greens of Zhuhai Jinwan golf course has been suggested. The study indicated a medium level of turf in respect to color, density, coverage, texture and mowing height and rather long recovery period. Tee had a composite score of 25 points and the evaluation level achieved was III. The coverage, density, texture, and mowing height of the fairway were evaluated as well, and the uniformity, color, and recovery cycle were generally evaluated. The comprehensive score was 25 points and the evaluation level has been given a score of level III. The uniformity, coverage, density and texture of green were basically good, and had a short recovery period. The score of mowing height was poor and ball speed was low. Green's composite score was 27 points with an evaluation level III. The overall turf quality of Zhuhai Jinwan golf course has been recognized to stay at an intermediate level.

1. Introduction

Each functional area of golf course is composed of turf, which is formed by surface that covered by one to three different grass species. Turf is the foundation and has been considered as a rigid index to evaluate the quality of golf course. Golf course with ideal turf quality is competitive in the market. The quality of turf affects the operation and existence of the golf course which will directly affect the playing mood of players. Proposing a sound management schedule for the turf components of the golf course is very vital.

The study of Zheng *et al.* points out that a comprehensive system of turf quality assessment should include appearance quality evaluation, use quality evaluation and ecological quality evaluation [1]. Liu *et al.* propose an equation to explain the comprehensive evaluation value and weight assignment of the golf course turf quality. The equation is $v=0.25d+0.20t+0.10c+0.15u+0.30s$, in which d for density, t for texture, C for color, U for uniformity, s for smoothness [2]. As the quality evaluation system of the green has not been established in China, Wang *et al.* refer to the "Golf Course Quality evaluation standard" developed by the New Zealand Sports Turf Research Institute (NZSTI) to evaluate the quality of the golf course in Beijing Klauver base and make suggestions for improvement [3]. Yang *et al.* demonstrated that golf course green with function as the basis, based on the characteristics of the green, 6 index factors were determined, such as the green speed, hardness, disease area ratio, mowing height, smoothness and appearance quality, and an objective and simple



evaluation method for the quality of the green turf was established through the experiment [4]. The method is used to evaluate the green of Qinling International Golf Club. The results show that the system can evaluate the real situation of the quality of green turf with accuracy, objectivity and simplicity. The conservation improvement measures based on the measured data are effective and have higher use value. The study on turf quality evaluation and maintenance management of Changsha Green Bamboo Lake Golf Course by Liu provides a program reference for this study [5]. Duan's research points out that the course must conduct regular professional inspection and analysis, find out the problem in time to maintain customer satisfaction and train the staff to promote the improvement of turf maintenance management [6]. Zhang mentioned that high quality turf cannot be separated from efficient turf machinery management, professional turf machinery storehouse management and mechanical maintenance management is also an effective way to control the increase of turf maintenance cost in terms of long-term benefits [7]. Dr. James B Beard comprehensively analyzes golf course management skills and provides recommendations in his book [8].

The schedule must contain the results of assessment of growth condition for the turf. Zhuhai Jinwan golf course has been considered to be an attractive course but it needed an immediate assessment on the turf growth condition and quality. The present research has therefore been undertaken to assess the current quality grade of turfs and to suggest the management schedule. This would help the management team of Zhuhai Jinwan golf course to implement the management procedure showing the further requirements of turf stuff, turf equipments, etc.

2. Research methods and contents

2.1. Experiment object

The experiment was carried out in Zhuhai Jinwan golf course located in Jinwan district Zhuhai city. The climate of the area is subtropical monsoon having high annual temperature, humidity and with abundant rainfall. The annual relative humidity of the area is 79.75% and the total rainfall is 2009.3 mm. The study area has basically no winter, on an average seven months are summer (i.e., April to October) and 5 months are spring and autumn (i.e., November to March). The tee, fairway and green of the golf course are composed of Seashore Paspalum (*Paspalum vaginatum* Sw., Fam.: Poaceae). It is a warm season turf grass species

2.2. Experiment indexes and methods

Similar to standard golf course, Zhuhai Jinwan golf course has 27 holes throughout the tees, fairways and greens. A total of randomly selected 6 holes from tees, fairways and greens bearing numbers 2, 8, 10, 19, 23 and 26 were selected for the present investigation.

The experiment was started on 20 October 2017 and took 4 days to complete. Among all the experimental indices, the experiment period of the recovery was extended until the selected turf of a quadrat returned completely returned to the initial states of the experiment by itself. All measurements were taken during the morning, which is most players' tee time.

An iron framed quadrat of 10 cm² area was used to collect data from the tees, fairways and greens. The quadrat was tossed randomly to each area of the golf course and data on color, density, coverage, texture, mowing height, uniformity, elasticity, ball speed on the green and recovery ability of the turf were recorded. Five replicate measurements were carried out in each of the 6 holes of the golf course. Of the 9 measured parameters, the uniformity, color and coverage were graded after visual inspection. The density index's method was used, whereby a needle was stabbed into the turf and the leaves of the turf grass that touched the needle were counted (n=10). To grade the grass leaves width, texture index was used. Mowing height index was measured by using a ruler (n=6). The bounding height was measured following the elasticity index assessment method, which was carried out by dropping a golf ball freely from a height of 1.3 m on the turf and the bounding height was recorded (n=3). A Speedmeter was used to measure the ball speed index (n=3). Assessing the recovery ability was point out the pitches in the tees and fairways and ball marks on the green, then recorded week number that

pitches and ball marks recovered same state compare with the surrounding turf, got 6 pitches and 3 ball marks at each hole. Assessment of recovery ability in the pitches of tees and fairways and the ball marks of greens was done by selecting having same size and degree of injury present. All pitches and ball marks were then monitored for weeks until the pitch and ball mark recovered to the same state as compared with the surrounding turf.

2.3. Turf quality appraise standard

In the process of evaluation of turf quality, it is difficult to quantify the importance indexes of turf color and uniformity in comparison, judgment, evaluation and decision making. In order to simplify and synthesize multi-research results, this experiment has been combined with customary 5-points grading evaluation standard to build golf course turf quality grading standard (Table 1). After rating by table 1, the Jinwan Golf Course turf quality grade was determined according to the rating of table 2.

Table 1. Grading standards of turf quality of golf courses.

Indices	Standards (points)				
	5	4	3	2	1
Color	Blackish green	Dark green	Green	Light green	Olivine
Density (leaves)	≥ 4	3	2	1	0
Texture (mm)	≥ 1.5	1.6-2.0	2.1-2.5	2.6-3.0	> 3
Coverage (%)	> 98	98-95	04-90	89-85	< 85
Green mowing height (mm)	< 3.0	3.0-3.5	3.6-4.0	4.1-4.5	> 4.5
Fairway mowing height (mm)	< 10	10-15	16-20	21-25	> 25
Tee mowing height (mm)	< 9	9-12	13-16	16-20	> 20
Uniformity	High	Above	Normal	Lower	Lowly
Ball speed on the green (m)	≥ 3.04	2.74-3.03	2.44-2.73	2.13-2.43	< 2.13
Recovery ability (week)	< 1	1-2	2-3	3-4	> 4

Table 2. Turf grades of golf courses.

Grade	Score	
	Tee and Fairway	Green
I (great)	32-35	36-40
II (good)	28-31	31-35
III (general)	24-27	26-30
IV (poor)	19-23	20-25
V (very poor)	≥ 18	≥ 19

3. Results and discussion

3.1. Appraise results of the turf quality on Tees

The first shot played on the tee in a hole, which is usually considered as an important one. Tee's uniformity, color and texture will affect players' visual impact and golfing mood as it is the first part of the golf course that golf players reach, making tee become quite important.

As can be seen from Table 3, the uniformity of tees was good and scored 4 points. The colour is dark green and scored 4 points. The average coverage on the tee of Jinwan golf course was around 95%, and a score of 4 can be assigned and so as to density. The average mowing height on tee of Jinwan golf course was 13.23 mm, and had an assigned score 4 points. According to the measurement, the average leaf width of the turf grass was 1.93 mm. This ensured better texture and a point of 4 was scored accordingly. Since the experimental period covered mid-to-late October, the growth season of *P. vaginatum* passed. The turf species was about to enter the dormancy period, therefore, average 3

weeks of recovery were needed. The score 2 points was got. The ball rebounding height on the tee was 6.37 cm.

Table 3. Appraise results of turf quality on tees of Jinwan golf course.

Indices	Experimental hole numbers						Average	Score
	2	8	10	19	23	26		
Uniformity	Above	High	Popularly	Above	Above	Above	Above	4
Colour	Green	Dark green	Green	Dark green	Dark green	Dark green	Dark green	4
Coverage (%)	93	99	92	94	95	98	95.1	4
Density (leaves)	4(± 0.80)	3(± 0.40)	3(± 0.97)	4(± 1.12)	3(± 0.51)	2(± 0.24)	3	4
Texture (mm)	1.77 (± 0.05)	2.01 (± 0.07)	1.86 (± 0.05)	1.89 (± 0.06)	2.06 (± 0.09)	1.96 (± 0.05)	1.93	4
Mowing height (mm)	15.6 (± 0.05)	14.1 (± 0.05)	12.2 (± 0.05)	12.2 (± 0.04)	13.2 (± 0.06)	12.1 (± 0.05)	13.23	3
Rebounding height (cm)	7.87 (± 0.59)	7.3 (± 0.39)	5.77 (± 0.29)	5.43 (± 0.31)	6.33 (± 0.43)	5.53 (± 0.28)	6.37	/
Recovery ability (week)	3	4	3	3	4	3	3.3	2

3.2. Appraise results of the turf quality on fairways

Usually, the fairway is the largest consistent part of any golf course. Therefore, the quality of fairway greatly influences the selection and use of the golf course by the consumers.

Table 4. Appraise results of turf quality on fairways of Jinwan golf course.

Indices	Experimental hole numbers						Average	Score
	2	8	10	19	23	26		
Uniformity	Normal	Above	Normal	Normal	Above	Normal	Normal	3
Colour	Olivine	Dark green	Olivine	Green	Above	Light green	Green	3
Coverage (%)	93	95	92	97	98	96	95.1	4
Density (leaves)	2(± 0.68)	3(± 0.49)	3(± 0.32)	4(± 1.29)	2(± 0.93)	4(± 1.29)	3	4
Texture (mm)	1.74 (± 0.07)	1.8 (± 0.07)	1.91 (± 0.07)	1.83 (± 0.08)	2.14 (± 0.09)	1.79 (± 0.06)	1.87	4
Mowing height (mm)	13 (± 0.05)	12.6 (± 0.04)	11.7 (± 0.05)	11.1 (± 0.05)	12.7 (± 0.05)	11.5 (± 0.06)	12.1	4
Rebounding height (cm)	11.43 (± 0.37)	9.43 (± 0.61)	13.6 (± 0.42)	11.4 (± 0.33)	18.97 (± 0.78)	14.97 (± 0.93)	13.3	/
Recovery ability (week)	2	3	4	3	3	4	3	3

Table 4 shows that the uniformity of the fairways was normal and individual fairway even appeared bare land so the score was 3 points. The color of the fairways turf by visually measured was green, the score was 3 points. The overall density of the fairways turf was above with 4 points of score. The turf grass on fairways was a little bit long and the mowing height was 12.1 mm that's why it got 4 points. Visual inspection showed a better coverage of the turf which acquired 4 points. The texture of turf grass at the fairways was above and stayed in the middle and upper level. Since the experimental period did not cover the growth season which usually requires 3 weeks to recover. The average ball rebounding height of the fairway was 13.3 cm.

3.3. Appraise results of the turf quality on greens

The green is the most important part of golf course. The putting on the greens is usually considered the key to winning a hole. It can be seen from Table 5 that Jinwan golf course's greens were highly in uniformity, no uneven color, uneven density and uneven grass length issues were observed. So, it scored uniformity point 5. The colour of the green's grass was green and got 3 points score, this was happened because of low mowing height. The coverage of the greens was high to 99%, higher than normal golf courses, which usually demand 98% coverage. The measured mowing height was 5.7 mm which was significantly different from the 3.2 mm which is recommended by the turf department. So, the score was 1 point according to the grading standard. High level golf competitions require the green speed faster than 3.35 m, the green speed of Jinwan golf course was 2.45 m, which is little lower than the recommended and so received only 3 points. The green recovery period was short and can be restored in about 1 week. In this case, the score was 4 points. The rebounding height of the tee and fairway was recorded as 6.67 and 13.3 cm, respectively. When these values are compared with the value of green (4.02 cm), the latter is found low. This kind of situation is more beneficial to the professional player because they can keep a control on ball. Due to the lacking of other literature information on the rebound height data of different golf courses, it became impossible to discuss and interpret the information obtained in the present research.

Table 5. Appraise results of turf quality on green of Jinwan golf course.

Indexes	Experimental hole numbers						Average	Score
	2	8	10	19	23	26		
Uniformity	High	Above	Above	High	High	High	High	5
Colour	Green	Green	Green	Green	Olivine	Dark green	Green	3
Coverage (%)	98	100	98	98	100	100	99	5
Density (leaves)	2(± 0.51)	2(± 0.55)	2(± 0.60)	3(± 0.29)	2(± 0.37)	2(± 0.58)	2	3
Texture (mm)	1.75 (± 0.06)	1.85 (± 0.06)	1.77 (± 0.06)	1.67 (± 0.05)	1.68 (± 0.05)	1.64 (± 0.05)	1.73	4
Mowing height (mm)	5.8 (± 0.03)	5.9 (± 0.02)	5.8 (± 0.02)	5.5 (± 0.02)	5.3 (± 0.02)	5.6 (± 0.01)	5.7	1
Rebounding height (mm)	3.3 (± 0.32)	3.8 (± 0.24)	4.53 (± 0.26)	3.6 (± 0.20)	4.53 (± 0.25)	4.33 (± 0.23)	4.02	/
Ball speed on the green (m)	2.36 (± 0.03)	2.71 (± 0.03)	2.46 (± 0.04)	2.49 (± 0.06)	2.36 (± 0.03)	2.31 (± 0.05)	2.45	3
Recovery ability (week)	1	1	1	1	1	1	1	4

In summary, the tees of Jinwan golf course are graded with all moderate degrees, uniformity, colour, coverage, density and texture. It has a good appraisalment in mowing height, but the recovery period is too long. The comprehensive score of tees was 25 with an evaluation grade III level. Fairways got good appraisalment in coverage, mowing height, density and texture, but got medium appraisalment in uniformity, colour, and recovery ability. The overall score was 25 points having evaluation grade III level. And green's uniformity, coverage, density, texture and recovery ability were basically good, however, poor appraisalment in mowing height, ball speed on the green a little low, comprehensive score of greens was 28, level III.

The overall quality of Jinwan golf course is at a medium level.

4. Investigation on maintenance and management of golf course

4.1. Irrigation

Moisture content is the key to high quality golf turf, so everyday irrigation is an essential task for the turf department of Jinwan golf course. When turf is dry, its surface will harden, color will turn to olivine, trampling footprints becomes more visibly and ball's rebounding height will be higher. Especially, when the green turf is at low mowing height every day, the roots system will become shallower and the water absorption and holding capacity will decrease. Automatic sprinkler system is utilized in Jinwan Gold Course, through which the tee and fairway are irrigated when it is dark and the green is irrigated before business time. The practice is continued once in a day for 15-20 mins, if not rainy. At the commencement of hot weather, supplemented artificial irrigation is carried out in the golf course as turf lacks of water.

4.2. Mowing

The turf maintenance department of the Jinwan golf course depends upon the seasonal climate. Last year, the growth of the grasses was set in an annual turf mowing-height plan (Table 6). However, the actual green mowing-height was measured 5.7 mm in October, which is far higher than the annual plan (Table 6). In the meantime, measured ball speed on the green was 2.45 m and the mowing-height has severely affected the speed of the green. It happened because of the mowing technique of the green keeper was not qualified and the mower blades were older which caused ball speed slower than expected.

Table 6. Jinwan golf course annual turf mowing-height schedule.

Area	Mowing-height (mm)	Frequency		Time
		May-Oct.	Nov.-Apr.	
Tee	May-Oct: 10-11; Nov.-Apr.:13	3-4 times/week	1 time/week	
Fairway	May-Oct: 10-11; Nov.-Apr.:13	3-4 times/week	1 time/week	5:30-6:00
Green	May-Oct:2.1; Nov.-Apr.:2.5	1 time/day	3-4 times/week	

4.3. Topdressing and rolling

Theoretically, there is no seasonal limit for topdressing and rolling. In order to ensure green grass's benign growth and faster ball speed, the frequency of topdressing should be directly proportional to the growth rate of green grass. The topdressing and the rolling frequency should be average i.e., once in a week and the thickness of topdressing should be maintained 2-3 mm each time. However, in Jinwan golf course, the topdressing of greens were carried out once in a moth except the competition seasons. The thickness of the topdressing has been recommended as 1 mm on topdresser's scale, but in reality it did not fulfill the scale in the Jinwan golf course. This is another reason that the ball speed is not qualified. The authority used to carry out topdressing tees 2-3 times in a year and fairways once

in a year. The same practice has also been carried out in case of the maintenance of the greens. As a result, the actual thickness of topdressing is less than 2 mm.

4.4. Coring

Coring not only alleviates the degree of soil compaction, but also cuts the stolons to stimulate the growth of the new stolons to the turf grass. This practice promotes the formation of a dense turf, which is suitable for the spring when the grass turns to green. At the same time, coring increases the permeability of the soil and the ability to seep water, allowing the root system to absorb nutrients faster and better, and further promotes the growth of greens. In addition, coring can control the turf thatch to avoid excessive moisture in the thatch layer which might cause rotting in the roots of the turf. Rotting can affect the growth of the new root system of the turf and eventually may lead to infectious diseases. Table 3 indicates the coring performance of the golf turf in the Jinwan golf course.

Table 7. Jinwan golf course turf coring survey.

Area	Core diameter (mm)	Core depth (mm)	Core type	Frequency
Tee	5	8	Hollow	2 times/year (spring/winter)
Fairway	10	8	Hollow	2 times/year (spring/winter)
Green	4	8	Hollow	2 times/year (spring/winter)
			Solid	Only when turf water permeability deteriorates

5. Conclusion

Through the appraise study of the turf quality of Jinwan golf course and comprehensive analysis of the work of the turf maintenance department, it revealed that the turf quality of Jinwan golf course was at intermediate level. The limiting factors of scoring are the uniformity, mowing height and recovery ability of the tee and fairway turf and mowing height, ball speed of the green.

Jinwan golf course should appraise turf quality regularly, and the maintenance schedule should be adjusted in time according to the results. It is also necessary to establish professional turf maintenance equipment, regular inspection and a strict follow up maintenance schedule. Inspecting and repairing all the turf related equipment on the golf course regularly and timely. Otherwise, upgrading will be required when equipment failed to meet the needs of turf maintenance standards. To pay attention to the details of the implementation of turf maintenance measures, such as whether, the thickness of the topdressing is made up to the standard, and whether the mowing height calibration on mower is consistent with the actual mowing height. What's more, the time of the green irrigation should be fixed as far as possible, avoid the excessive numbers of people playing golf in morning to delayed irrigation time to noon and led to grass burns. The particle size of sands of topdressing should be chosen in accordance with the green's construction and quality.

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