

FIFA Maintenance Research 2013

Results equipment suppliers

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1. Introduction

FIFA have undertaken an assessment of the effects of different maintenance machines on Football Turf fields. A series of Football Turf Fields that have a similar usage were located in the Western part of France. The fields chosen have a similar daily usage and obviously being geographically located within the same region are exposed to similar environmental and climatic conditions. The aim of the study was to test the fields prior to the maintenance procedure, test immediately after the maintenance procedure to avoid any effects from individuals playing on the field then test them again 1 month later to ascertain whether or not there had been any long-term effects on the field as a result of the maintenance procedure.

Field Locations

Rennes – Square de Berry
 Rennes – Stade Salengro
 Laval – Gandonniere
 Laval – Hippodrome
 Le Mans – Fontennelle
 Angers – Stade de l’Arceau
 Angers – Bertin

Field	Date of Installation	Usage (hours/day)	Club/School (%) / (%)	Shockpad
Square de Berry	2010	35	25/75	Yes
Stade Salengro	2009	16	100/0	Yes
Gandonniere	2010	12	100/0	No
Hippodrome	2004	30	75/25	No
Fontennelle	2005	18	100/0	No
Stade de l’Arceau	2008	24	50/50	No
Bertin	2010	24	25/75	No

Testing Protocol

There were 4 basic types of machine used:

- A combined heavy vertical brush with a steel sprung tine rake attached behind.
- An oscillating brush system
- A rotating brush system
- A triangular brush was the fourth maintenance technique employed.

Each field was sub-divided into 4 quadrants. Each of the 3 maintenance machine manufacturers was allocated a quadrant with the fourth quadrant maintained either by a triangular brush or a straight vertical brush.

Tests were undertaken using the FIFA Quality Programme Manual (2011 Edition). The tests chosen were specifically to assess the effects of the maintenance machines on the fields.

Testing Procedure	Maintenance Effect on System Component
Ball Rebound	Performance Infill and Fibres
Ball Roll	Fibres
Force Reduction	Performance Infill
Deformation	Performance Infill
Energy Restitution	Performance Infill
Rotational Resistance	Performance infill and fibres

2. Results

2.1. Force Reduction - Rennes Square du Berry

Date		01.07.13		02.07.13			07.08.13			
Air Temperature	°C	23		17.8			23.2			
Surface Temperature	°C	24.1		22			27.9			
Humidity	%	58.1		51			69			
Surface Condition		Dry		Dry			Dry			
Wind Speed	m/s	0.3		0.3			0.2			
Force Reduction										
Quadrant	Position					% Change			% Change	
		%								
1	A	%	64.2		66.1	2.96	↑	66.2	3.12	↑
1	B	%	62.4		64.2	2.88	↑	63	0.96	↑
1	C	%	65.5		64.2	-1.98	↓	66.2	1.07	↑
					Ave	1.29		Ave	1.72	
2	D	%	62.9		64.1	1.91	↑	65	3.34	↑
2	E	%	62.5		61.7	-1.28	↓	63.9	2.24	↑
2	F	%	65.1		66.3	1.84	↑	64.9	-0.31	↓
					Ave	0.82		Ave	1.76	
3	G	%	63.5		65	2.36	↑	65.5	3.15	↑
3	H	%	65		64.5	-0.77	↓	61.6	-5.23	↓
3	I	%	66.1		66.7	0.91	↑	65	-1.66	↓
					Ave	0.83		Ave	-1.25	
4	J	%	64.7		67.4	4.17	↑	65.6	1.39	↑
4	K	%	62.7		65.2	3.99	↑	64.2	2.39	↑
4	L	%	66.3		65.6	-1.06	↓	65.1	-1.81	↓
					Ave	2.37		Ave	0.66	

The results are presented as a % change of the absolute value compared to the original value obtained. In position A for example when re-tested on the 02.07.13 the Force Reduction had increased from 64.2 to 66.1, representing an overall relative increase of 2.96%. Whereas in position C the Force Reduction had decreased from 65.5 to 64.2, when tested on 02.07.13, an overall relative decrease of 1.98% and hence it is represented as a negative number.

2.2. Force Reduction (Immediately after maintenance)

Average % change for Force Reduction achieved using the different techniques (immediately after maintenance)

	Rotating Brush	Δ	Average
Sq du Berry	1.29	0.82	1.33
Salengro	0.57	2.11	0.62
Gandonniere	-5.9	0.65	-1.56
Hippodrome	4.85	0.1	0.85
Fontenelle	5.87	4.17	3.59
Stade de l'Arceau	3.16	-3.01	-1.23
Bertin	-1.88	0.39	-0.17
Average	1.14	0.75	0.49

The relative changes to Force Reduction are generally relatively small. The overall change shows that 68% of the areas measured had an increase in Force Reduction immediately after maintenance. The rotating brush produced an increase in 71% of the areas whereas the other techniques generated an increase in 57% of the areas measured. The rotating brush also produced the greatest average and individual increase as well as decrease. The overall average for the rotating brush was a relative increase of 1.14% with a maximum relative increase of 5.87% and a maximum relative decrease of 5.9%. The oscillating brush and the triangular brush both had an overall average relative increase of 0.16%, ranging from 3.42% to -2.51%, and 0.49%, ranging from 3.59% to -1.56%, whereas the combined brush and rake had an overall average relative decrease of 0.08%, ranging from 2.37% to -2.54%. Fontenelle showed the greatest initial change with an average 3.59% relative increase.

2.3. Force Reduction (1 month after maintenance)

Average % change for Force Reduction achieved using the different techniques (1 month after maintenance)

	Rotating Brush	Δ	Average
Sq du Berry	1.72	1.76	0.72
Salengro	-1.56	-1.26	-0.85
Gandonniere	-7.65	-0.77	-3.07
Hippodrome	4.53	-0.87	-0.57
Fontenelle	0.47	1.5	0.20
Stade de l'Arceau	-1.94	-4.45	-3.57
Bertin	1.03	1.03	-0.22
Average	-0.49	-0.44	-1.05

In contrast the Force Reduction appears to have reduced in 64% of the locations 1 month after maintenance. The triangular brush areas appear to be the least effected at a relative average of -0.44%, ranging from -4.45 to 1.5%. The changes are relatively small.

2.4. Deformation (Immediately after maintenance)

Average% change for Deformation achieved using the different techniques (immediately after maintenance)

	Rotating Brush	Δ	Average
Sq du Berry	-1.59	-2.52	-2.40
Salengro	4.44	5.35	4.07
Gandonniere	-10.38	-1.24	-2.65
Hippodrome	4.96	0.21	0.71
Fontenelle	-3.65	-5.31	-7.09
Stade de l'Arceau	2.46	-2.25	-1.69
Bertin	-8.68	-6.89	-7.24
Average	-1.78	-1.81	-2.33

71% of the areas measured showed a drop in Deformation with a maximum relative decrease of 11.2% recorded. The largest relative increase recorded was 5.99%. The combined brush and rake machine produced the greatest overall average change with a relative average drop of -3.08%, ranging from -11.2% to 1.9%. The rotating brush showed the least relative change with -1.78%, ranging from -10.38% to 4.44%. Both Fontenelle and Bertin showed similar average relative reductions in Deformation of -7.09% and -7.24% respectively.

2.5. Deformation (1 month after maintenance)

Average % change for Deformation achieved using the different techniques (1 month after maintenance)

	Rotating Brush	Δ	Average
Sq du Berry	3.4	5.06	1.51
Salengro	0.74	-2.45	0.78
Gandonniere	-8.51	0.17	-2.25
Hippodrome	6.56	0.6	0.60
Fontenelle	-7.97	-6.15	-8.95
Stade de l'Arceau	-7.95	-7.1	-8.75
Bertin	-1.92	-2.2	-4.25
Average	-2.24	-1.72	-3.04

After 1 month the relative average change for Deformation remains negative for all machines and locations with 68% of areas tested showing a relative reduction in Deformation when compared to the original values recorded. The oscillating brush showed the greatest relative decrease ranging from -11.64% to 0.53%. The triangular brush showed the least relative change with an average of 1.72%, ranging from -7.1% to 5.06%. Fontenelle and Stade de L'Arceau showed the greatest change from the original values with -8.95% and -8.75% respectively.

2.6. Energy Restitution (Immediately after maintenance)

Average % change for Energy Restitution achieved using the different techniques (immediately after maintenance)

	Rotating Brush	Δ	Average
Sq du Berry	-0.66	0.99	1.41
Salengro	-15.34	-18.9	-16.92
Gandonniere	0.25	-5.74	-3.80
Hippodrome	-10.31	-8.96	-7.46
Fontenelle			
Stade de l'Arceau	-0.18	5.39	2.30
Bertin			
Average	-5.25	-5.44	-4.89

75% of the values recorded showed a decrease in Energy Restitution immediately after maintenance. The most profound reduction being in Salengro with an average reduction of 16.92% ranging from -15.34, for the rotating brush to -18.9% for the triangular brush. Interestingly the scatter of values between the different machines is relatively small for Salengro.

2.7. Energy Restitution (1 month after maintenance)

Average % change for Energy Restitution achieved using the different techniques (1 month after maintenance)

	Rotating Brush	Δ	Average
Sq du Berry	1.63	3.19	5.27
Salengro	-6.56	-4.11	-6.08
Gandonniere	9.54	3.92	5.72
Hippodrome	-1.16	1.09	3.21
Fontenelle			
Stade de l'Arceau			
Bertin			
Average	0.86	1.02	2.03

Salengro is still recording a significant reduction in Energy Restitution and Gandonniere a significant increase in Energy Restitution.

2.8. Ball Rebound (immediately after maintenance)

Average % change for Ball Rebound achieved using the different techniques (immediately after maintenance)

	Rotating Brush	Δ	Average
Sq du Berry	2.48	4.74	4.10
Salengro	-5.65	-0.89	-2.77
Gandonniere	-11.23	-6.21	-9.43
Hippodrome	4.79	7.91	4.78
Fontenelle	1.34	2.41	0.72
Stade de l'Arceau	-2.56	-4.98	-4.43
Bertin	-0.87	2.66	-0.02
Average	-1.67	0.81	-1.01

The effect of the maintenance machines on Ball Rebound on the various the surfaces was evenly split with 48% of values recorded showing an increase. The most consistently pronounced change was noted for Gandonnieres. The field was dry on the initial test and wet on the 1st re-test. The overall average changes are relatively small.

2.9. Ball Rebound (1 month after maintenance)

Average % change for Ball Rebound achieved using the different techniques (1 month after maintenance)

	Rotating Brush	Δ	Average
Sq du Berry	0.85	-0.09	2.19
Salengro	0.32	1.7	0.63
Gandonniere	0.97	-0.31	-0.96
Hippodrome	6.35	12.19	8.66
Fontenelle	0.7	-1.8	0.11
Stade de l'Arceau	-1.28	-3.35	-3.54
Bertin	1.82	1.34	0.73
Average	1.39	1.38	1.12

When re-tested after 1 month the Hippodrome showed on average a significant relative increase of 8.66%, ranging from 6.8 to 12.19%. The weather conditions were similar for the original and final tests with the 1 month test being a few degrees warmer 34.1 compared to 25.7°C surface temperature and a reduced Relative Humidity of 23 rather than 55%, albeit that both days are recorded as dry.

2.10. Ball Roll (immediately after maintenance)

Average % change for Ball Roll achieved using the different techniques (immediately after maintenance)

	Rotating Brush	Δ	Average
Sq du Berry	-7.98	-12.24	-10.78
Salengro	-13.61	-7.41	-11.34
Gandonniere	-19.26	-6.68	-12.38
Hippodrome	5.96	0.5	-10.82
Fontenelle	-12.82	-8.99	-17.46
Stade de l'Arceau	-9.2	-2.82	-9.79
Bertin	-18.4	-16.84	-19.02
Average	-10.76	-7.78	-13.08

Significant changes to the ball roll were recorded immediately after maintenance ranging from an average relative reduction of -9.79% at the Stade de L'Arceau to -19.02% at Bertin. The oscillating brush generated the greatest overall relative average change at -19.12% ranging from -13.3% (Salengro) to -31.83% at the Hippodrome. The triangular brush had the least effect with an overall relative average of -7.78% ranging from 0.5% to -16.84%. The rotating brush recorded an average of -10.76% ranging from 5.96 to -19.26%. The combined brush and rake had an overall average change of -14.67% ranging from -8.45% to -23.98%.

2.11. Ball Roll (1 month after maintenance)

Average % change for Ball Roll achieved using the different techniques (1 month after maintenance)

	Rotating Brush	Δ	Average
Sq du Berry	7.15	-3.79	0.26
Salengro	9.71	14.63	9.21
Gandonniere	5.32	7.9	7.93
Hippodrome	12.64	9.32	1.95
Fontenelle	0.29	6.17	1.32
Stade de l'Arceau	-5.25	-0.75	-4.27
Bertin	-7.74	-4.87	-5.29
Average	3.16	4.09	1.59

After 1 month the reduction in the ball roll had changed to an overall average increase for 3 of the machines values and only the oscillating brush retained an overall small reduction with values ranging from 11.34 to -13.02%. The overall average increase was recorded at Salengro with an average increase of 9.21% ranging from 2.77% for the area maintained by the oscillating brush to 14.63% using the triangular brush.

2.12. Rotational Resistance (immediately after maintenance)

Average % change for Rotational Resistance achieved using the different techniques (immediately after maintenance)

	Rotating Brush	Δ	Average
Sq du Berry	2.65	-2.74	-0.70
Salengro	11.82	6.86	10.18
Gandonniere	-5.65	3.39	-0.74
Hippodrome	12.66	13.31	10.90
Fontenelle	-2.83	-9.04	-5.64
Stade de l'Arceau	2.68	-7.11	-2.33
Bertin	-5.41	-8.17	-6.67
Average	2.27	-0.50	0.71

Salengro showed a pronounced increase in Rotational Resistance for all the maintenance machines, ranging from 6.86% for the triangular brush to 14.61% for the combined brush and rake. Similarly Hippodrome, showed a pronounced increase in Rotational Resistance for all the maintenance machines, ranging from 8.29% for the combined brush and rake to 14.61% for the triangular brush. In contrast Fontenelle showed a decrease for all the machines from -2.83% for the rotating brush to -9.04% for the triangular brush. The effects were however split with only a 54% increase in Rotational Resistance recorded. The overall average increase was a small increase for all but the triangular brush which recorded a small reduction in the overall average value.

2.13. Rotational Resistance (1 month after maintenance)

Average % change for Rotational Resistance achieved using the different techniques (1 month after maintenance)

	Rotating Brush	Δ	Average
Sq du Berry	9.1	3.35	7.35
Salengro	19.33	9.17	13.76
Gandonniere	10.22	14.1	11.56
Hippodrome	16.48	12.53	12.85
Fontenelle	2.88	4.52	1.39
Stade de l'Arceau	6.61	0.07	2.29
Bertin	-2.08	-5.19	-3.78
Average	8.93	5.51	6.49

Square du Berry, Salengro, Gandonniere and Hippodrome all showed a significant increase in Rotational Resistance 1 month after installation when compared to the initial values. The overall averages for the 4 machines for all fields used also showed a significant increase 1 month after installation.

3. Summary

3.1. Shockpads

Two of the fields had shockpads namely Rennes Square du Berry and Rennes Salengro which have reportedly 12mm pre-fabricated rubber shockpads. Le Mans Fontenelle has a Terram layer between the base and the synthetic turf.

3.2. Force Reduction

The initial values for Force Reduction are higher for the fields with the 2 shockpads varying from 62.4 to 66.3 at Rennes Square du Berry and 62.4 to 65.1% at Rennes Salengro. In contrast the fields with no shock pad varied from as low as 45.1 -53.4 at Le Mans Fontennelle to 50.9 – 57.3 at Laval Gandonnieres, 46.9 to 54.7 at Laval Hippodrome, 52.3 to 58.9 at Angers Stade L'Arceau and 52.6-59.4 at Angers Bertin. Immediately after maintenance the 2 fields with shockpads showed a small increase in Force Reduction, Square du Berry (1.33%) and Salengro (0.62%). The fields without shockpad showed an average reduction in Force Reduction for 3 fields, namely Gandonniere (-1.56%), Stade L'Arceau (-1.23%) and Bertin (-0.17%) and an average increase for the other 2 fields, Hippodrome (0.85%) and Fontenelle (3.59%).

All the changes in general are quite small and are of statistically of little relevance. The only significant changes occurred on the field at Fontenelle which was the lowest recorded values which showed an average increase of 3.59% and in particular the area prepared by the rotating brush which showed an increase of 5.87%. Similarly at the Hippodrome the rotating brush achieved an increase of 4.85%.

After 1 month 2 fields showed increases and the remainder on average decreases albeit all the average changes were relatively small with the exception of average reductions of -3.07% at Gandonniere and -4.59% at Stade L'Arceau.

The systems designed to meet the FQP requirements for Force Reduction at installation that used a shockpad remained within the FQP limits. Without a shockpad those fields that were below the FQP limits prior to the maintenance work remained below the limits after the maintenance work, namely Laval Gandonniere, Laval Hippodrome and Le Mans Fontennelle. The fields without shockpad that were initially above the FQP limit, Angers 1 and 2, stayed above the FQP limit after the maintenance procedure, however after 1 month's further usage the field at Angers Stade de L'Arceau went below the FQP limit generally whereas Stade Bertin remained within the FQP limit.

In conclusion for these fields with high usage and little or no regular maintenance the fields tested with shockpads remained above the minimum FQP requirement. The changes achieved by the maintenance techniques in general had only a marginal effect on the Force Reduction values recorded. There were no noticeable long term effects from the maintenance techniques employed. It would therefore appear that the intensity of use has a more pronounced effect on the loss of Force Reduction of the field than the maintenance techniques used. Those fields that are below the minimum level for the FQP may potentially benefit from a more intensive maintenance routine than the time that was given to each field. It would be interesting to know what the original Force Reduction values recorded were when the fields were installed to ascertain what has taken place over the lifetime of each field.

3.3. Deformation

All the results for Deformation remained within the FQP 1 Star category before maintenance, immediately after maintenance and 1 month after maintenance. The values ranged from 5.8-10.4 mm with, as would be expected, the lowest values recorded on the hardest fields and the highest values on the "softer" fields

with shockpads. The initial Deformation for the 2 fields with shockpads varied from 9-10.4 mm for Rennes Square de Berry and 9.1-9.8 mm for Rennes Salengro. In contrast the fields with no shock pad varied from 6.1-7.6 mm at Le Mans Fontenelle to 6.6-7.7 mm at Laval Gandonnieres, 5.8-7.3 mm at Laval Hippodrome, 7-8.4 mm at Angers Stade L'Arceau and 7.2-8.7 mm at Angers Bertin. 71.4% of the values recorded immediately after maintenance showed a reduction in Deformation. The most noticeable changes being at Fontenelle with an average change of -7.09% varying from -3.65% to -11.2% and Bertin with an average of -7.24% varying from -5.32% to -8.68%. The combined brush and rake overall had a -3.08% average change varying from 0.5% to -11.2%, oscillating brush with an average of -2.65% varying from 5.99% to -8.19%, rotating brush average of -1.78% varying from 4.96% to -10.38% and finally the triangular brush average of -1.81% varying from 5.35% to -6.89%. The systems with shockpads recorded an increase on average of 4.07% ranging from 0.5% to 5.99% for Salengro and –a decrease on average of -2.4% ranging from -1.59 to -2.95% for Square de Berry.

After 1 month the overall change remains at 71.4% reduction, varying from 6.56% to -11.64%. Fontenelle had on average a -8.95% reduction varying from -6.15 to -11.64%, Stade L'Arceau on average -8.75% varying from -7.1% to -11.55% and Stade Bertin on average -4.25% varying from -1.92% to -8.03%. The combined brush and rake prepared areas showed an average -2.91% change varying from 4.28% to -10.03%, the oscillating brush average of -5.31% varying from 0.53% to -11.64%, the rotating brush average of -2.24% varying from 3.4% to -8.51% and the triangular brush average -1.72% varying from 5.06% to -7.1%.

An increase in Deformation would normally be associated with a loosening of the granular infill structure allowing the shoe to penetrate further into the infill. Conversely a decrease in the Deformation would be associated with a consolidation of the granular infill and thus a reduction of the penetration of the shoe into the surface. With an overall decrease of 71.4% immediately after maintenance it would appear that the techniques used are consolidating the infill for most of the systems. The exceptions being Rennes Salengro, on a shockpad, which showed a small increase and hence loosening of the infill and Laval Hippodrome which had an average increase, albeit that 2 of the values were an increase and 2 were a decrease. Less pronounced changes to Deformation appear to be associated with the 2 systems that had shockpads.

3.4. Energy Restitution

75% of the average results showed a decrease in Energy Restitution ranging from a decrease of -0.15% to -18.9%, the areas that increased in Energy Restitution ranged from +0.25% to +5.47%. Salengro recorded the highest change with an average decrease of -16.92% ranging from -15.34% to -18.9%. There was little difference between the averages for the 4 techniques, combined brush and rake -4.13%, oscillating brush -4.75%, rotating brush -5.25% and the triangular brush at -5.44%.

After 1 month Salengro remained on average less than original tested with an average value of -6.08% varying from -4.11% to -8.88%. Gandonniere recorded an average increase of +5.72% ranging from +3.92% to +9.54%. 62.5% showed an increase on the original results recorded.

There was no obvious difference in the change of performance of the surfaces with or without shockpads with regard to the change in Energy Restitution.

Energy Restitution as the name implies refers to that characteristic of the surface that returns energy after the impact. As a general principle, non-deforming hard surfaces tend to have a high energy restitution as little is absorbed by the surface on impact conversely non-elastic energy absorbing surfaces have low energy restitution as they have absorbed the energy of impact. A decrease in Energy Restitution after maintenance can occur if the performance infill was less compacted and "looser" in structure resulting in a dissipation of the impacting force. If no further maintenance took place then the infill would re-compact

and the energy restitution would be expected to return to similar values to those originally recorded before any maintenance had taken place.

3.5. Ball Rebound

Immediately after maintenance 48% of the values recorded showed an increase. The values varied from a decrease of -11.23% to an increase of +8.11%. The most noticeable were that recorded for the Hippodrome with an average increase of 4.78% varying from 2.27% to 7.91%, Square de Berry with an average increase of 4.1% varying from 1.05% to 8.11% and Laval Gandonnieres with an overall decrease of -9.43% varying from -6.21% to -11.23%. The combined brush and rake recorded an overall small decrease of -1.61% varying from -10.13% to +17.38%, the oscillating brush recorded an overall average decrease of -1.39% varying from +2.27% to -10.26%, the rotating brush recorded an overall average decrease of -1.67% varying from +4.79% to -11.23% and the triangular brush an average decrease of +0.81% varying from -6.21% to +7.91%. The presence of shockpads does not appear in this study to have had a pronounced effect from the different maintenance techniques.

After 1 month the most significant average change relates to the Hippodrome with an average increase of +8.66% varying from +6.8% to +12.19% the largest average decrease was recorded at Stade L'Arceau with an overall reduction of -3.54% varying from -1.28% to -6.25%. From the results recorded the average values increased for 55.5% of the locations.

Ball Rebound varies according to several factors; firstly the overall hardness of the surface, secondly if the fibres are upright or flat and thirdly the weather conditions particularly the presence of moisture and the temperature of the surface. The 2 systems with shockpads recorded values of 0.8 to 0.91 and 0.808 to 0.916. The systems without shockpads gave values of Gandonnieres 1.04-1.12, Hippodrome, 1-1.09, Fontennelle 1.09-1.12, Stade L'Arceau 1.01-1.096 and Stade Bertin 0.99-1.04. Clearly the presence of a shockpad has a pronounced effect on retaining the installed ball rebound values where no maintenance and intensive usage of the fields has taken place. The 2 techniques that would be expected to work the fibres the most, namely oscillating and rotating brushes had a small decrease on the overall rebound the other 2 techniques had a small average increase in Ball Rebound. After the initial maintenance the Gandonnieres and Stade L'Arceau field were sufficiently improved as to meet the FQP Ball Rebound requirements for a 1 Star field however Hippodrome, Fontennelle and Stade Bertin remained above the requirements. After 1 month only the quadrants maintained by oscillating brush and dragbrush/rake at Stade L'Arceau and the 2 fields with shockpads met the FQP 1 Star requirements for Ball Rebound. In conclusion for those fields with high usage and little or no regular maintenance the fields tested with shockpads remained above the minimum FQP requirement for all techniques. Certain specific techniques that raise the fibres can have a long term effect on certain locations but the effect is not guaranteed for all locations without continuing maintenance.

3.6. Ball Roll

Before any maintenance had taken place all the fields were above the 1 Star FQP limits for Ball Roll. Reductions in Ball Roll were recorded up to 31.83% using the oscillating brush conversely the rotating brush generated a 5.96% increase at the Hippodrome. After the initial maintenance Square de Berry recorded a reduction in Ball Roll but still no areas were within the FQP limits. Salengro also recorded a reduction in Ball Roll, 1 out of 3 were now within the limits for the rotating brush and the triangular brush. Gandonnieres also had a general reduction with 1 out of 3 areas on the limit for the rotating brush. At the Hippodrome 67% recorded a reduction with the rotating brush recording an increase in all 3 areas and the triangular brush recording an increase for 1 out of 3 areas; the oscillating brush produced 3 areas all within the limits and the combined brush and rake 1 out of 3 areas within the limits. Le Mans continued the trend for a general reduction with the oscillating brush producing 1 out of 3 areas on the limit. 1 of the areas for

the triangular brush showed an increase the remainder showing a decrease in Ball Roll at Stade L'Arceau; the oscillating brush had 2 out of 3 areas within the limits. Finally at Stade Bertin all showed a decrease but no areas came to within the limits. The most significant average change -19.02% occurred at Stade Bertin with a variance of between -16.84% for the triangular brush to -21.52% for the oscillating brush. After the initial maintenance the fields gave average reductions with lowest recorded average change of -9.79% for Stade L'Arceau.

After 1 month 50% of the areas still recorded a reduction in Ball Roll with all 4 areas at both Stade L'Arceau and Stade Bertin still recording a reduction on average of -4.27% and -5.29% respectively. However on average the other 5 fields recorded an average increase in Ball Roll albeit rather small for 3 of the remaining 5, namely Square de Berry average +0.26%, Hippodrome +1.95% and Fontenelle +1.32%. The combined brush and rake produced an average change of +0.15% varying from a reduction of -6.04% to an increase of +9.72%. The oscillating brush gave an average of -1.05% varying between -13.02% to +11.34%. The rotating brush average +3.16% varying from -7.74% to +12.64% and finally the triangular brush average +4.09% varying from -4.87% to +14.63%.

In conclusion significant changes to Ball Roll can be achieved by all the techniques; the most effective change was produced by the oscillating brush and the least by the triangular brush. The effects achieved are however only sustainable if maintenance is continued on the fields as the evidence would indicate that the fields will return to their original condition if they continue to be neglected after a relatively short period of time. From the maintenance undertaken the presence of a shockpad would appear to have no specific effect on retaining Ball Roll over time. Ball Roll is a sensitive indicator to the condition of a Football Turf field and if the field is under-maintained and over-used this is one characteristic of the surface that will inevitably fall out of the limits of the FQP and it is not always possible to retrieve the correct level of performance even with advanced maintenance techniques.

3.7. Rotational Resistance

All the results recorded either before, immediately after or after 1 month for all the fields are within the FIFA 2 Star requirements. This is the only test that shows all the fields are within the higher of the 2 FIFA standards in all 3 conditions. The average change in values recorded for Rotational Resistance immediately after maintenance split into 3 categories. Two fields recorded a significant increase of +10.18% at Salengro and +10.90% at the Hippodrome. Three fields recorded a small average decrease, namely Square de Berry -0.7%, Stade L'Arceau -2.33% and Gandonniere -0.74%. The last 2 fields showed an overall reduction of -5.64% at Fontenelle and -6.67% at Stade Bertin. These values are clearly independent of shockpads as Salengro and Square de Berry are in different groupings. The rotating brush produced an average increase of +2.27%, the combined brush and rake +0.80%, the oscillating brush +0.28% and the triangular brush a reduction of -0.50%.

After 1 month all the fields showed an average increase in Rotational Resistance varying from +1.39% at Fontenelle to +13.76% at Salengro, Stade Bertin was the only exception with an overall decrease of -3.78%. Stade Bertin was -6.67% immediately after maintenance so the Rotational Resistance had increased between the initial maintenance and the 1 month re-test.

Rotational Resistance clearly indicates the grip the boot, hence the player, feels when it interacts with the surface. The higher the grip the higher the torque measured by the Rotational Resistance device. If the studs penetrate into an infill that is consolidated then a higher torque value will be recorded. If the studs cannot penetrate through the rubber infill or the penetration into the rubber infill is reduced due to over-compaction of the infill the studs will rotate relatively unopposed and produce a lower torque value. If the studs penetrate into a relatively loose rubber infill but do not penetrate the sand below because of the depth of the infill then the torque value will be reduced as a consequence due to the reduction in resistance to the movement of the measuring device. However if the infill is either too loose or the depth of

the infill is too thin the studs will penetrate into the sand layer beneath the rubber upper layer resulting in potentially too much grip. Initially therefore it would appear that in 5 of the fields the infill is being loosened and less resistance is experienced by the studs. In 2 fields the infill has been loosened and the studs are likely penetrating into the sand layer. The loosening is a temporary effect and after 1 month the numbers have increased again due to heavy usage and a lack of maintenance.

4. Conclusions/Recommendations

1. Without the continuing correct maintenance from the installation through the lifetime of the field it was not possible to ensure that the surfaces tested remained within the limits defined by the FIFA Quality Programme even after the use of more sophisticated maintenance techniques.
2. The use of the shockpads on these fields without maintenance but with significant usage could only guarantee certain characteristics of the FIFA Quality Programme. The most significant being the performance characteristics relating to impacts namely Force Reduction and Ball Rebound.
3. 4 maintenance techniques were assessed, namely drag brush, drag brush/steel rake, rotating brush and oscillating brush. The most significant overall improvement on the various surfaces on Ball Roll was achieved with the oscillating brushes. The least effect albeit an improvement in Ball Roll was with a basic drag brush. However even with the oscillating brush it was not possible in the timeframe in which the machines operated to return all the fields to within the requirements of the FQP.
4. The changes to Force Reduction achieved by the maintenance techniques in general had only a marginal effect on the Force Reduction values recorded. There were no noticeable long term effects from the maintenance techniques employed. It would therefore appear that the intensity of use and long term lack of maintenance has a more pronounced effect on the loss of Force Reduction of the field than a singular use of a more sophisticated maintenance technique.
5. An overall decrease in Deformation immediately after maintenance would appear to imply that the techniques used are consolidating the infill for most of the systems. Less pronounced changes to Deformation appear to be associated with the 2 systems that had shockpads.
6. Conversely a decrease in Energy Restitution after maintenance was recorded for most of the systems suggesting that the performance infill was less compacted and "looser" in structure resulting in a dissipation of the impacting force.
7. In conclusion significant changes to Ball Roll can be achieved by all the techniques; the most effective change was produced by the oscillating brush and the least by the triangular brush. The effects achieved are however only sustainable if maintenance is continued on the fields as the evidence would indicate that the fields will return to their original condition if they continue to be neglected after a relatively short period of time. From the maintenance undertaken the presence of a shockpad would appear to have no specific effect on retaining Ball Roll over time. Ball Roll is a sensitive indicator to the condition of a Football Turf field and if the field is under-maintained and over-used this is one characteristic of the surface that will inevitably fall out of the limits of the FQP and it is not always possible to retrieve the correct level of performance even with advanced maintenance techniques.
8. When testing Ball Rebound those fields with high usage and little or no regular maintenance the fields tested with shockpads remained above the minimum FQP requirement for all techniques. Certain specific techniques that raise the fibres, oscillating and rotating brushes and to a lesser extent rakes and drag brushes, can have a long term effect on certain locations but the effect is not guaranteed for all locations without continuing maintenance.

9. After the initial maintenance it would appear that in 5 of the fields the infill is being loosened and less resistance is experienced by the studs resulting in a reduction in torque and a lower value for Rotational Resistance. In 2 fields the infill has been loosened and the studs are likely penetrating into the sand layer and thus increasing the torque. The loosening is a temporary effect and after 1 month the numbers have increased again due to heavy usage and a lack of maintenance.