



## SHORT COMMUNICATION

Precision Turfgrass Management and New Technology

# Surface performance characteristics of carpet-mat stabilized cool-season sod over drainage cells for temporary stadium installation

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**Abstract**

Carpet-mat systems are a diverse group of hybrid stabilizing systems that are installed during sod establishment. In this experiment, eight hybrid, carpet-mat systems (Flexgrass, Hatko Turfgrass XL BIO 40/34/10 [Turfgrass BIO], Hatko Hybridgrass 40 DS 10 XL [Hybridgrass 40 XL], Hatko Hybridgrass 53 DS 10 XL [Hybridgrass 53 XL], HG Turf Group HERO 127.127 [HERO 127], HG Turf Group HERO 169.169 [HERO 169], Tarkett Sports PlayMaster, POWERgrass™ SP/T [POWERgrass]) were screened for their suitability as a playing surface option for FIFA tournaments. Research was conducted at Michigan State University (MSU) and the University of Tennessee (UT). In fall 2023, carpets were seeded with perennial ryegrass (*Lolium perenne* L.) and established over plastic. Carpets were infilled with a graded, 90:10 (sand:peat) root zone to each carpet manufacturers prescribed depth. In spring 2024 (<12 months after seeding), established sod was harvested and transplanted to a cellular drainage testing block over asphalt. Treatments were evaluated for surface hardness, rotational resistance, and soccer ball rebound. At UT, treatments had no effect on surface hardness; however, both HERO treatments registered higher rotational resistance than all other carpets. At MSU, all carpet-mats, but HERO 169, generated a harder playing surface than the non-stabilized control but had no effect on rotational resistance. Ball rebound was unaffected by any treatment at either location. Based on current FIFA thresholds for an excellent quality pitch, all carpet-mat systems we evaluated following initial establishment could be considered a suitable hybrid option as a playing surface for a FIFA tournament venue.

## 1 | INTRODUCTION

Hybrid turf is a natural turf system that is stabilized by synthetic fibers extending into the natural turf canopy. Carpet-mat

systems are an evolved form of hybrid that vertically orients synthetic fibers at a fixed spacing into a mat laid horizontally over the root zone surface (Baker, 1997; Thoms et al., 2021). Carpets have been noted to improve divot resistance (McNitt & Landschoot, 2005; Serensits et al., 2011; Sherratt et al., 2005), surface hardness, and saturated hydraulic conductivity

**Abbreviations:** CIV, Clegg impact value; MSU, Michigan State University; UT, The University of Tennessee.

(Minner & Hudson, 2005) and prolong stability after excessive wear (Thoms et al., 2021). Once the carpet is installed by a grower, they can be established and harvested in the same manner as a non-stabilized sod product.

For the FIFA World Cup 2026, hybrid-stabilized, natural playing surfaces are a requirement (FIFA, 2021). The playing surface at eight of the 16 host venues is currently synthetic. For such venues, the synthetic surface and infill will be removed, leaving an exposed concrete or asphalt surface. As these natural turf conversions are often temporary, the installation of a gravel and sand root zone could be viewed as impractical and laborious. Cellular drainage systems, like Permavoid, are a unique alternative that offers comparable performance and characteristics of a conventional sand root zone (Young et al., 2022). The primary objective of this experiment was to evaluate the suitability of various carpet-mat systems for their use in the FIFA World Cup 2026. To emulate natural-conversion playing surfaces that will be featured in the FIFA World Cup 2026, we established sod into several carpet-mat systems and evaluated the surface performance characteristics of each over the Permavoid cellular drainage system.

## 2 | MATERIALS AND METHODS

### 2.1 | Treatment establishment

In fall 2023, perennial ryegrass (*Lolium perenne* L.) sod was established over plastic in eight carpet-mat systems (Flexgrass, Hatko Turfgrass XL BIO 40/34/10 [Turfgrass BIO], Hatko Hybridgrass 40 DS 10 XL [Hybridgrass 40 XL], Hatko Hybridgrass 53 DS 10 XL [Hybridgrass 53 XL], HG Turf Group HERO 127.127 [HERO 127], HG Turf Group HERO 169.169 [HERO 169], Tarkett Sports PlayMaster, POWERgrass™ SP/T [PowerGRASS]) at the Michigan State University (MSU) Hancock Turfgrass Research Center, East Lansing, MI, and the University of Tennessee (UT) East Tennessee Research and Education Center, Knoxville, TN. In August (MSU) and September (UT), three-mil plastic was laid over a graded surface and divided into nine, 21 m<sup>2</sup> quadrats. A thin blinding layer of engineered, 90:10, sand:peat root zone (infill) was spread across the surface and each carpet was cut to size, laid, anchored, and infilled to each manufacturer's prescribed (Table 1). Final sand depth of the non-stabilized control was 4.5 cm. Infill for all stabilized treatments ranged from 2.5 to 4.5 cm. Seed was applied in two directions using a drop spreader, calibrated to deliver two pure live seeds of Benchmark perennial ryegrass (*Lolium perenne* L.) cm<sup>-2</sup>. Shortly following seeding, MSU experienced abnormally wet and hot conditions, which resulted in some seed washout and poor germination. Subsequently, treatments were seeded with an additional 1 PLS cm<sup>-1</sup> in early-spring 2024. The site was

### Core Ideas

- Carpet-mat systems evaluated in this trial are suitable playing surfaces for sports fields.

fertilized with 98 kg ha<sup>-1</sup> Polyon N (43-0-0) and 98 kg ha<sup>-1</sup> P<sub>2</sub>O<sub>5</sub>. During establishment, the site was irrigated to prevent wilt and received an additional 98 kg N ha<sup>-1</sup>. Plots were mown to 3.2 cm, three times weekly using a rotary mower.

### 2.2 | Experimental initiation

In spring 2024, cells of Permavoid 85S (28 cm × 28 cm × 8.9 cm) were installed over an asphalt testing surface and wrapped in a capillary geotextile. Note that 8 (UT) and 10 (MSU) months after seeding, three, 0.6 m × 0.9 m pieces of each treatment were harvested from established quadrats and then transplanted over Permavoid. Treatments were arranged as a one-way, randomized complete block design with three replicates of each treatment.

### 2.3 | Data collection

Treatments were evaluated for surface hardness, rotational resistance, and ball rebound. Due to the strong relationship that exists between soil moisture and surface performance characteristics (Rogers & Waddington, 1992; Tengbeh, 1993), all testing was conducted when volumetric water content of treatments fell between 15% and 25%.

Surface hardness was determined from the average Clegg impact value (CIV) of three drops of a 2.25 kg Clegg Impact Soil Tester across each plot. Peak rotational resistance (Nm) was determined from the average of two rotational tests measured using a Dennis Shear Strength Tester (Dennis). Ball rebound height (cm) was measured by recording audio from three, 2 m drops of a FIFA Al Rihla World Cup ball. The time ( $T$ , s) between the first and second bounce of each drop was used to calculate ball rebound, where:

$$\text{Ball rebound height (cm)} = 1.23 \times (T - 0.025)^2 \times 100$$

### 2.4 | Statistical analysis

All data were analyzed using the "Fit model" platform in JMP (JMP®, Version 17.2. SAS Institute Inc.). Analysis revealed significant differences between locations, therefore all parameters are reported by location. Means were separated using Fisher's protected least significant difference at  $\alpha = 0.05$ .

**TABLE 1** The effects of eight hybrid, carpet-mat systems on the surface performance of perennial ryegrass (*Lolium perenne* L.) sod grown on plastic, established at Michigan State University, East Lansing, MI, and University of Tennessee, Knoxville, TN, evaluated 10 and 8 months after seeding, respectively—Spring 2024.

| Carpet-systems (MSU <sup>a</sup> )     | Root zone infill depth <sup>b</sup> (cm) | Carpet fiber density (Fibers cm <sup>-2</sup> ) | Surface hardness (CIV <sup>c</sup> ) | Rotational resistance (Nm <sup>d</sup> ) | Ball rebound (cm) |
|--|--|---|--------------------------------------|--|-------------------|
| Flexgrass                              | 3.1                                      | 7   | 89ab                                 | 48                                       | 79                |
| Hybridgrass 40 XL                      | 2.5                                      | 7   | 94a                                  | 53                                       | 80                |
| Hybridgrass 53 XL                      | 3.6                                      | 7   | 89ab                                 | 55                                       | 82                |
| HERO 127                               | 4.1                                      | 4   | 90ab                                 | 53                                       | 81                |
| HERO 169                               | 4.1                                      | 3   | 72cd                                 | 57                                       | 75                |
| Non-stabilized control <sup>e</sup>    | 4.1                                      | —   | 66d                                  | 55                                       | 65                |
| PlayMaster                             | 3.6                                      | 4   | 79bc                                 | 50                                       | 76                |
| POWERgrass                             | 4.5                                      | 8   | 71cd                                 | 57                                       | 80                |
| Turfgrass BIO                          | 2.5                                      | 7   | 86ab                                 | 55                                       | 79                |
| $p \leq 0.05$                          |  |   | ***                                  | NS                                       | NS                |
| <b>Carpet-systems (UT<sup>f</sup>)</b> |  |   |                                      |  |                   |
| Flexgrass                              |  |   | 83                                   | 46ab                                     | 84                |
| Hybridgrass 40 XL                      |  |   | 87                                   | 42b                                      | 82                |
| Hybridgrass 53 XL                      |  |   | 75                                   | 45ab                                     | 77                |
| HERO 127                               |  |   | 68                                   | 50a                                      | 79                |
| HERO 169                               |  |   | 79                                   | 51a                                      | 89                |
| Non-stabilized control                 |  |   | 66                                   | 39b                                      | 81                |
| PlayMaster                             |  |   | 76                                   | 47ab                                     | 84                |
| POWERgrass                             |  |   | 68                                   | 42b                                      | 75                |
| Turfgrass BIO                          |  |   | 79                                   | 39b                                      | 81                |
| $p \leq 0.05$                          |  |   | NS                                   | *  | NS                |
| <b>FIFA EQP thresholds<sup>g</sup></b> |  |   | 70–85                                | 25–50                                    | 60–100            |

Note: Values sharing the same letter in a column are considered not statistically significant at the  $\alpha = 0.05$  level.

<sup>a</sup>MSU; Michigan State University, Hancock Turfgrass Research Center, East Lansing, MI.

<sup>b</sup>Root zone material infill depth as prescribed by the manufacturer. Installed at both research locations.

<sup>c</sup>Clegg impact value, typically representing peak deceleration of a 2.25 kg Clegg Impact Soil Tester hammer.

<sup>d</sup>Newton-meters of rotational force required to shear the natural turfgrass surface.

<sup>e</sup>Non-stabilized perennial ryegrass sod established in an engineered, 90:10 (sand:peat) infill over plastic.

<sup>f</sup>University of Tennessee, East Tennessee Research and Education Center, Knoxville, TN.

<sup>g</sup>Excellent quality pitch (EQP) thresholds developed by FIFA to gauge the playability and safety of a playing surface.

\* and \*\*\* denote significance at  $\alpha = 0.05$  and  $\alpha = 0.001$  levels, respectively. NS, not significant.

### 3 | RESULTS AND DISCUSSION

#### 3.1 | Surface hardness

The effects of carpet-mat systems on surface hardness are well reported (McNitt & Landschoot, 2003; Thoms et al., 2021). Surface hardness at UT was unaffected by any treatment (Table 1). At MSU, HERO 169 was the only treatment that did not outperform the non-stabilized control. This observation at MSU may be explained by the negative relationship that exists between natural turf cover and surface hardness (Holmes & Bell, 1986; Rogers et al., 1988; Reyneri & Bruno, 2003). The fiber density of the HERO 169 was 50%–60% lower than all treatments evaluated, possibly allowing for greater natural turf

cover and, thus, a softer surface. Despite no statistical differences between treatments at UT, the surface hardness of HERO 169 and non-stabilized control plots at both locations still achieved thresholds of an “excellent quality” (70–85 CIV) pitch by FIFA standards (FIFA, 2021).

#### 3.2 | Rotational resistance

The rotational resistance (shear strength) of grass is a good indicator of playing surface traction (Rogers et al., 1988; Guisasola et al., 2009). The consistency of measurements can vary between device and operator (Canaway & Bell, 1986). Since the Canaway device was first introduced, more

commonly available devices have emerged (Dickson et al., 2018; Ross et al., 1991; Thoms et al., 2021; Webb et al., 2014)—each designed with the intention of improving the consistency of measurement. In this experiment, treatment differences in rotational resistance were only observed at UT. Rotational resistance of both HERO products was  $\approx 30\%$  greater than the non-stabilized control. Similar observations have been made over artificial playing surfaces (Severn et al., 2010, 2011), where differences in peak rotational resistance between artificial systems corresponded with decreased synthetic fiber density.

### 3.3 | Ball rebound

Ball rebound was unaffected by any hybrid carpet-mat system across measurement periods and locations. For this parameter, FIFA suggests an optimum range of 60–100 cm for an excellent quality pitch (FIFA, 2021). Despite no significance, all treatments, locations, and periods yielded levels that fell within range of a FIFA “excellent quality” pitch.

## 4 | CONCLUSION

Although non-stabilized control treatments did not consistently underperform those stabilized, our data provide objective evidence that use of a hybrid carpet-stabilized sod would not result in reduced performance. Inconsistencies between locations may be explained by root zone differences. Although both research sites established treatments in an engineered, USGA spec root zone, the particle size distribution of an acceptable sand by these standards are broad. Moreover, slight differences in sand shape and angularity can also translate to differences in performance characteristics of a playing surface (Li et al., 2009). For these reasons, future work might consider using identical root zone across experimental years or between experimental sites. In addition, further work with carpets must consider organic matter management during establishment, the effects of infill depth, carpet integrity under simulated traffic, and other parameters unrelated to performance alone.

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### CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

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