Innovative Sports Technologies, Inc.

Shear Resistance of a Sports Surface Underlayment Panel with Grip Elements

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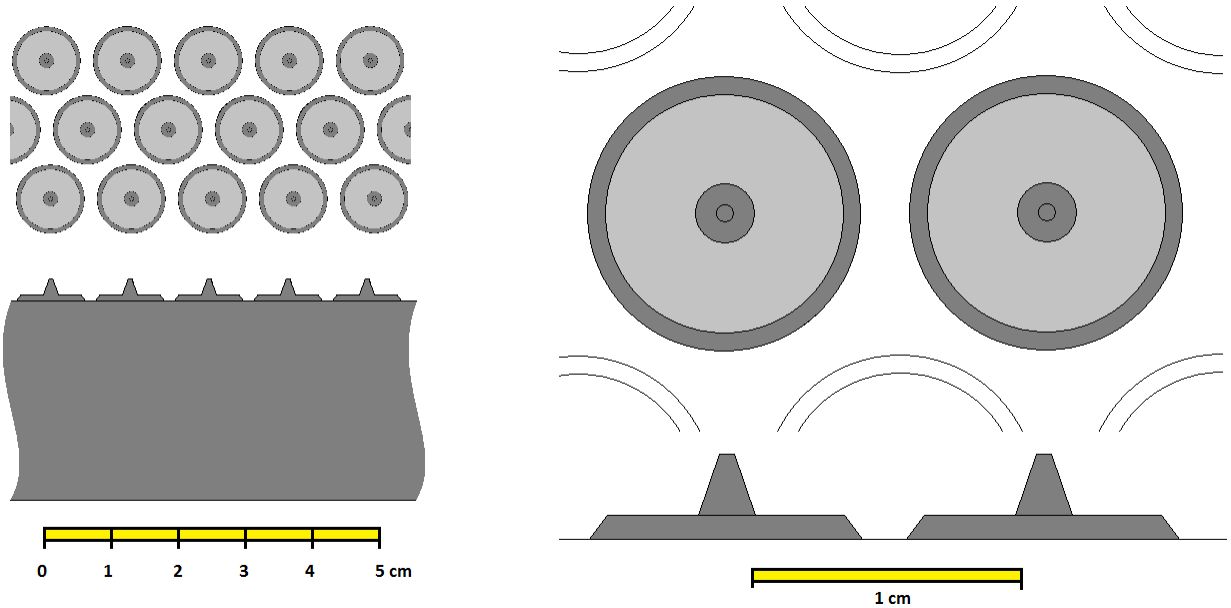
The report concerns the resistance to shear (horizontal) loads of a turf underlayment panel with grip elements. A sufficiently high level of shear resistance is required to prevent the overlying turf from sliding relative to the underlayment when horizontal forces are applied to surface by athletes of vehicles.

The surface of the underlayment panel incorporates spike-like grip elements, ~1 mm in diameter and ~2 mm high and spaced at ~15 mm intervals on a equilateral triangular grid. These elements are intended to penetrate the backing of overlying turf, gripping the turf in a manner that increases the effective friction between the two layers and increases shear resistance.

Sectional view of surface panel with overlying felt-backed artificial turf.

Grip elements on the upper surface of the panel.



Schematic of the grip element layout.
Scales are approximate.

Measurements

Shear resistance between the turf and the underlayment depends on several factors:

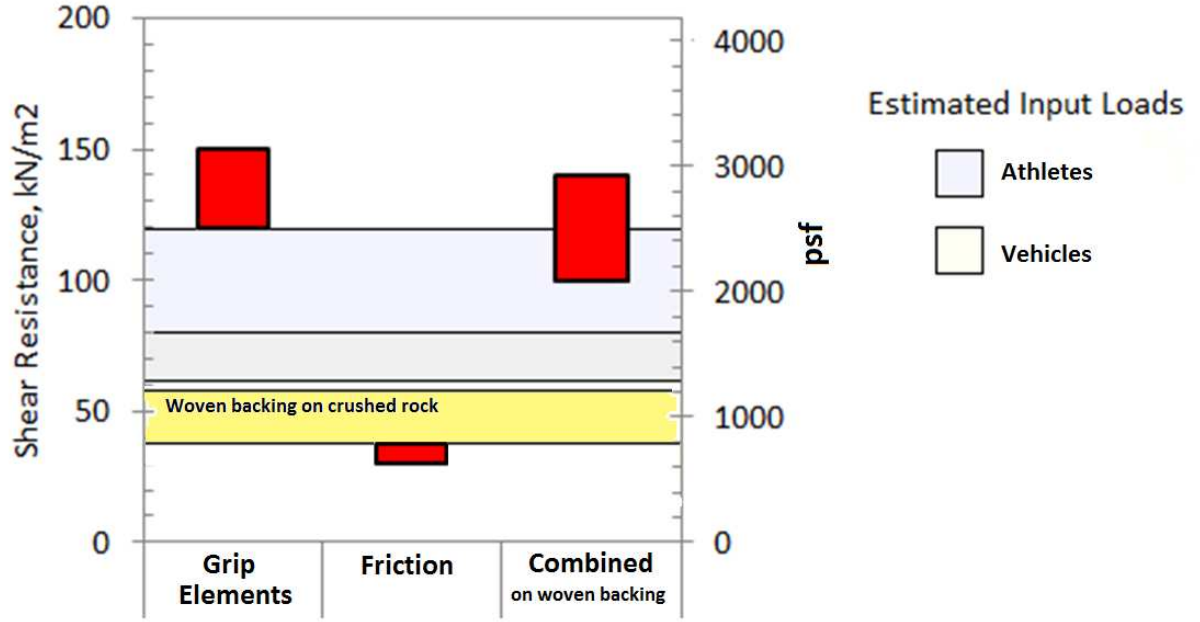
1. The coefficient of friction between the undersurface of the turf and upper surface of the underlayment (without the grip elements).
2. Shear strength of the grip elements – the amount of horizontal force an element can sustain without breaking.
3. Density of the grip elements – the number of elements per unit surface area.
4. Shear strength of the turf backing – how much horizontal force the backing can sustain without tearing or fiber separation that allows the grip elements to pass through.

Various mechanical tests and measurements were used to quantify each of these contributors to overall shear resistance.

Results

The chart below shows the ranges of various components of shear resistance, with the estimated range of shear loads that could be produced by athletes and vehicles as a reference.

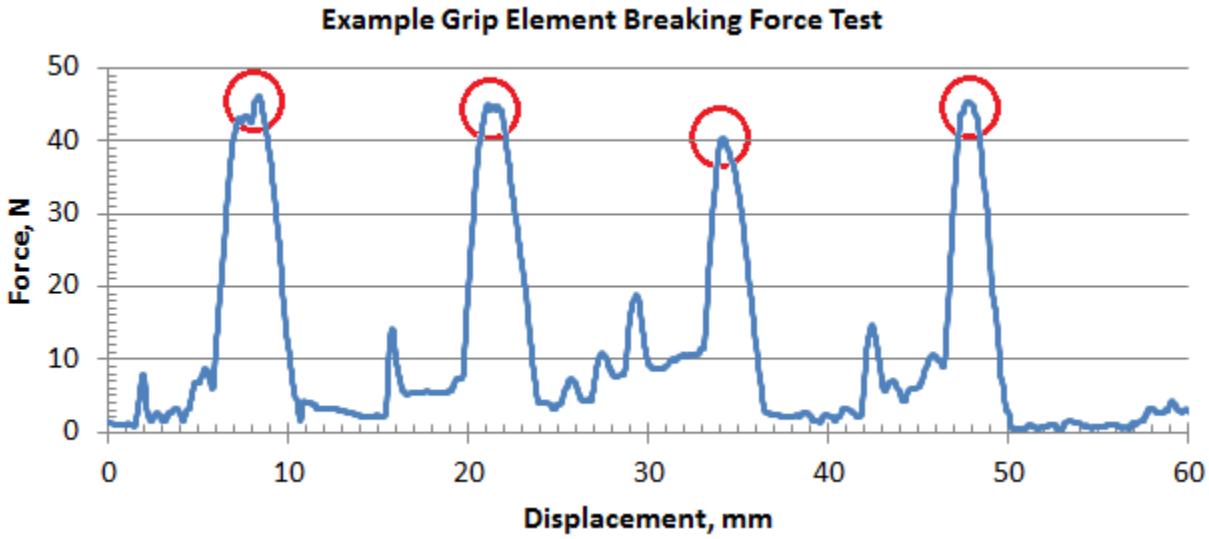
The maximum expected shear load is ~ 120 kN m^{-2}. The strength of grip elements comfortably exceeds this target. The elements can resist 120-150 kN m^{-2} of shear load without breaking. The friction between the bare surface and turf is relatively low but *adds* to the grip element strength, resulting in a healthy excess of shear resistance capacity. For comparison, the same woven backing on a crushed rock base has shear resistance of ~40-60 kN m^{-2}.



Grip Element Spacing	Direction 1 Direction 2 Density	~ 13.6 mm ~ 23.4 mm ~ 3200 per square meter ~ 300 per square foot
Grip Element Shear Strength	Breaking force, per element	42 N ± 3 sd 9.4 lb ± 0.7 sd
	Shear resistance	134 kN / square meter
		2800 psf
Woven Backing on Panel	Shear resistance	100-140 kN/square meter
		2090-2925 psf
Woven Backing on Crushed Rock	Shear resistance	40-60 kN/square meter 900-1100 psf

Conclusion

When used in combination with a turf that has a woven backing, the grip elements provided sufficient shear resistance to prevent relative slipping of the underlayment and the turf under most loading conditions. The additional resistance provided by inertia and other factors should result in a sufficient margin in excess of the expected shear resistance requirements.


Example Grip Element Breaking Force Test
Force, N
50
40
30
20
10
0
0
10
20
30
40
50
60
Displacement, mm