Permanent Deflection and Performance Study of Drivable Grass®

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ABSTRACT

This paper presents results from a permanent deflection and endurance study performed on a new paving system trademarked by Soil Retention Products, Inc. as Drivable Grass®.

A fire station in Oceanside, California was selected as the test site. The station has an adjacent truck washing area that has been recently paved with the Drivable Grass® system. This location offered the ability to control and/or measure: varying loads, drive passes, and the moisture percolation capability of the plantable concrete paving system. During the course of the study, the system was actually subjected to a higher load frequency and/or larger loads than would be expected over the "typical-use" service-life of the product.

This study used both qualitative and quantitative measures of the paving system's performance. Manometer readings and photographic documentation were used to evaluate how the concrete mat performed with the repeated loading of various fire trucks. Test results showed that only minor subgrade deflections and that the paving system completely maintained its structural integrity while providing the plantable and drivable surface for which it intends to accommodate.

INTRODUCTION

Soil Retention Products, Inc., headquartered in Carlsbad, California, holds both the patent and the Registered Trademark for this innovative and plantable concrete paving mat product.

Drivable Grass® is a permeable, flexible and plantable pavement system that consists of manufactured polymerically reinforced, concrete mats. The pavement mat attains tensile strength by incorporating polymer grids, spaced at 2-inches on center, that connect the concrete muffins (i.e., a raised concrete cube in the mat that supports most of the load). The polymer reinforcing allows the mat to maintain its tensile strength while also allowing large amounts of flexure facilitated by the linear grooves and holes between the muffins. These cracks and holes also allow for root penetration and moisture drainage. Typical uses include: fire lanes, service vehicle access driveways, overflow and recreational vehicle parking, patios, golf cart paths, residential driveways, roundabouts, vehicle wash areas, v-ditches, and other non-driving applications such as bio-swales and erosion control applications.

The study took place at an active-duty fire station where the pavement system was subjected to repeated loads from fire trucks. The purpose of this study was to provide qualitative and quantitative performance data of the paving system under these conditions.

Previous Studies

Soil Retention Products previously performed a study of the Drivable Grass® mat product at their manufacturing facility in Romoland, California. Construction of the test site began October 1, 2004, and focused on a 20-foot-wide by 30-foot-long section where subgrade soils consisted of silty sands with an R-value of 75. The installed pavement section consisted of the 1.5-inch-thick Drivable Grass® mat underlain by a 0.5- to 1.0-inch-thick sand leveling bed and a variable thickness of crushed miscellaneous base. A geotextile separator (Mirafi® HP570) was used to partition the pavement from the native materials.

For the study, all loaded aggregate delivery vehicles accessing Soil Retention Products' manufacturing plant drove directly over the test section. During the test period, delivery vehicles with a total weight of 80,000 lbs. and with tire pressures ranging from 85 to 120 psi, made approximately 800 passes over the pavement. At the completion of the test period, examination of the product indicated that the pavement mat performed well with no damage to the structural integrity being noted.

TEST SITE - OCEANSIDE FIRE STATION

Fire Station No. 5 on North River Road in Oceanside, California, is located adjacent to the San Luis Rey River and walking trail. In Spring 2005, the San Diego Regional Water Quality Control Board made the Oceanside Fire Department aware that the practice of washing fire trucks on the station's asphalt pavement was resulting in runoff draining directly into the riverbed. To temporarily mitigate the problem and contain the runoff, the fire station installed a gravel bed with a polyurethane geomembrane liner. The method proved to be ineffective, and other alternatives were considered by the Fire Department. Soil Retention's Drivable Grass® was chosen based on its ability to handle large vehicle loads and limit runoff by allowing water to infiltrate the pavement surface.

Photos, before and after, of the Drivable Grass® installation at the test site are shown below:

Figure-5: Fire Truck Wash Area – Before

Figure-6: Fire Truck Wash Area - After

CONSTRUCTION

Construction of the fire truck wash area was completed at the end of September 2005. Drivable Grass® concrete paving mat was installed underlain by a structural section consisting of 8 inches of Class II aggregate base course placed over a compacted subgrade. The subgrade was scarified to a depth of 6 inches, moisture conditioned, and compacted to at least 90% relative compaction. A separator fabric of Mirafi® HP-570 was placed between the subgrade and the aggregate base. The aggregate base was moisture conditioned and compacted to 95% relative compaction.

A 1.0- to 1.5-inch layer of sand and organics was overlaid on the aggregate base. The sand/organic layer was placed to facilitate grass growth through the paving system. The grooves and holes in the concrete mat allow roots to penetrate through the mat and reach the sand and organic soil mix. A “sand only” layer (i.e., with no organics) was used as a leveling course within the gravel area.

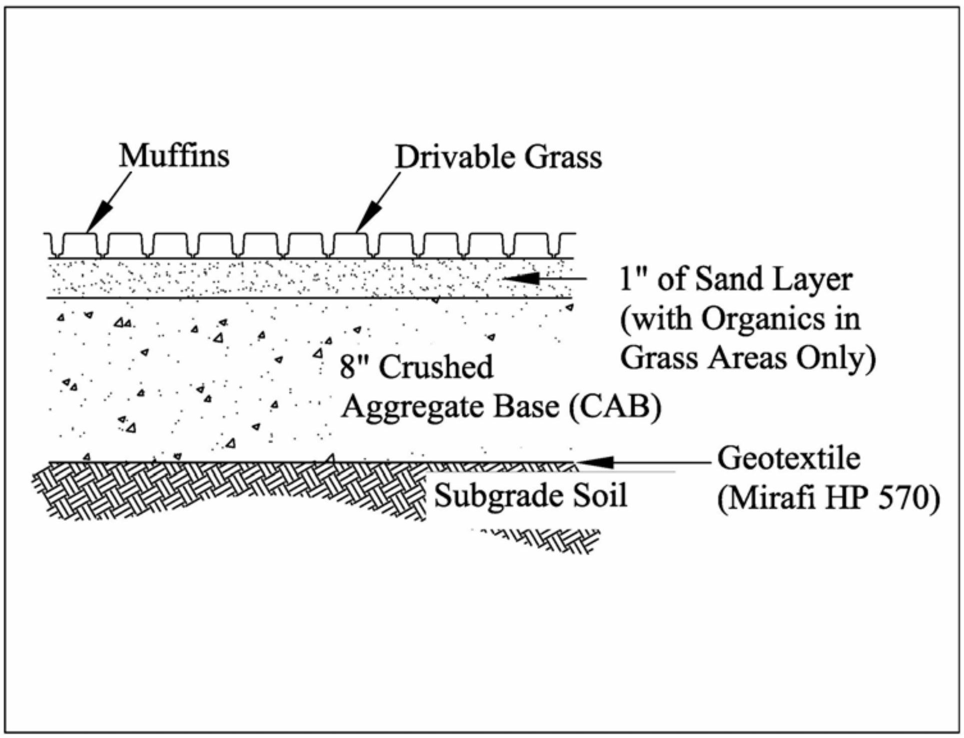

Figure-7: Cross Section of Pavement Section

The native subgrade consisted of two different soil types:

1. Dark olive clayey sand with gravel (SC) with a maximum dry density of 131.0 pcf (pounds per cubic foot), optimum moisture content of 9.5%, and an R-value of 77.

2. Dark brown clayey sand (SC) with a maximum dry density of 122.0 pcf, optimum moisture content of 12.0%, and an R-value of 71.

The unit weights and water contents were different for the two soils due to gravel content, but their R-values were fairly similar.

Pavement section design was based on the lowest R-value of 71. The design was completed using the Caltrans design method assuming a Traffic Index of 5.5. In addition, the City of Oceanside required an additional 1.0 inch of base material. Contribution of the Drivable Grass® mat was disregarded in computing the structural section.

Figure-8: Density Testing of Aggregate Base

Figure-9: Placement of sand/organic layer

Figure-10: Mat Installation

Figure-11: Infill Placement

There were three different types of infills used on top of the concrete mat:

1) sandy soil with grass seed
2) sod
3) pea gravel with varying amounts of cement binder

These different infills allowed for direct comparison both quantitatively and qualitatively between each section. It should be noted that the topper with organics was only used below Infill Areas 1 and 2 (see Figure-12).

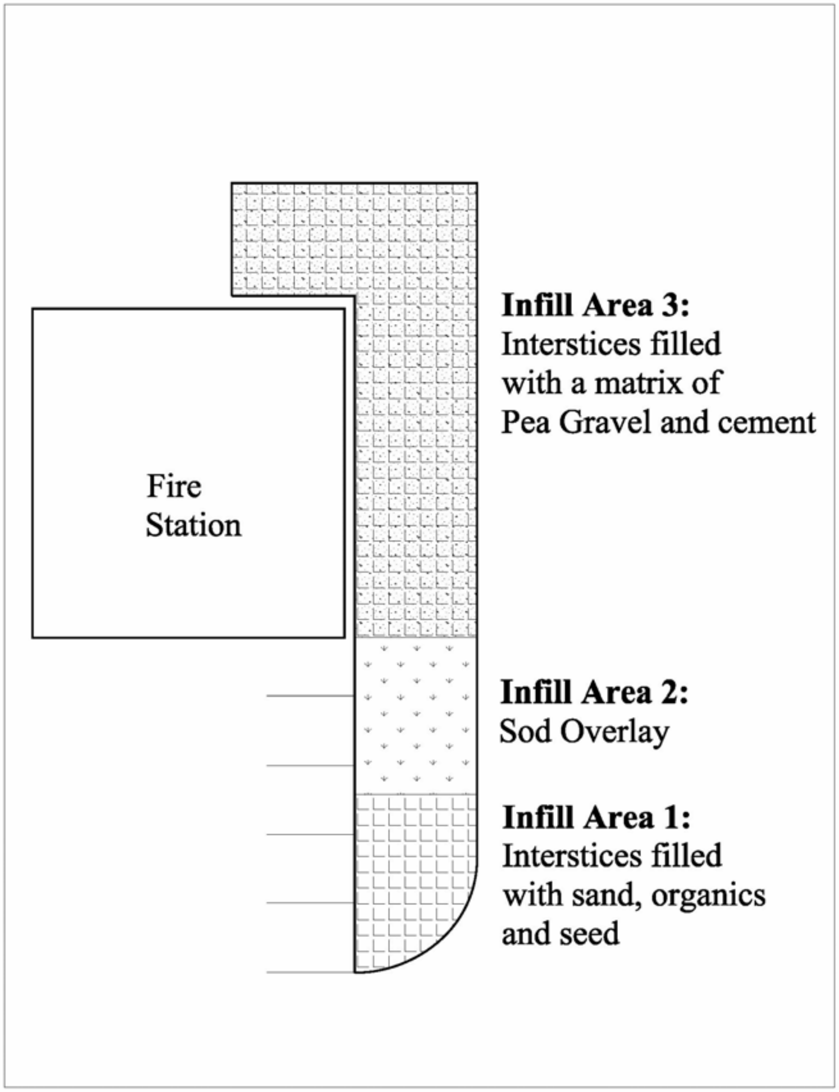

Figure-12: Infill Areas

Following the placement of the sod and seed within Infill Areas 1 and 2, the grass areas of the Drivable Grass® installation were cornered off and access was not allowed until the root systems were established.

POST-CONSTRUCTION

Originally, fire trucks were only allowed to be driven and washed within Infill Area 3. In January 2006, all infill areas was were opened to normal use, and conclusions were drawn from the acquired data. Figure-13 shows an example of the mats response to a load being applied by a fire truck. Below are the specifications for each fire truck that drove over the area:

Truck ID	Front GAW (lbs)	Rear GAW (lbs)	Front & Rear GVW (lbs)
F-80	18,740	24,000	42,740
F-64	19,940	29,280	49,220
F-74	12,000	23,000	35,000
F-48	14,400	24,000	38,400

Table-2: Fire Truck Loading

Figure-13: Fire Truck Loading

A visual inspection of the pavement surface was completed at each site visit. At no time was any cracking of the concrete muffins, or any visual signs of permanent deflection apparent. The total number of fire truck passes is tallied below:

Truck ID	11/09/2005	11/30/2005	12/15/2005	2/10/2006
F-80*	9	34	48	90
F-64*	0	23	23	33
F-74*	0	5	10	12
F-48*	0	0	0	6

Table-3: Fire Truck Passes by Date

**Additional passes were made and not logged,* ± *20% more.*

To measure any permanent deflection within the prepared subgrade and pavement system, manometer surveys were performed. A manometer can measure very small differences in elevation by recording relative water level changes. The accuracy of the measurement equipment is estimated as ∀0.2 inch. Measurements were taken on every other muffin cube on marked lines and charted by row number. The first reading was then set as a baseline and relative movement measurement was taken from that baseline.

Figure-14 shows the layout of the test area and the location of each of the measurement lines. Measurement charts are shown on Figures 15 through 19.

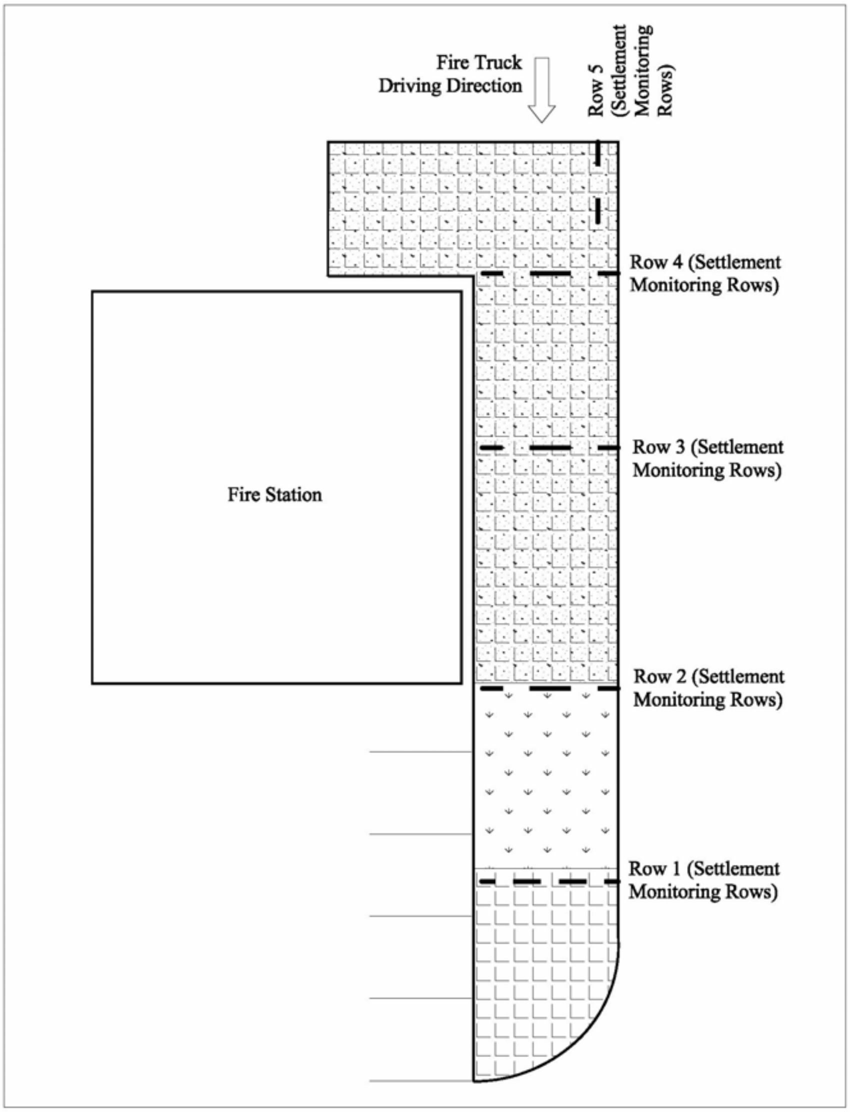

Figure-14: Deflection Measurement Lines

The first baseline reading was taken on September 28, 2005, before any driving use was allowed. Measurements were then taken throughout the next five months on November 9, 2005; November 30, 2005; December 15, 2005; and February 10, 2006.

Measurement charts for Rows 1 and 2 present readings for the grass planted sections of the concrete mat paved area (Figures 15 and 16). The rows are oriented perpendicular to the fire truck driving direction (Figure 14). The grass areas (i.e., Infill Areas 1 and 2) were opened to use at the beginning of January 2006, and have since had more than 50 truck passes. As seen in Figures 15 through 19, most of the movement falls within the tolerance limit of the survey (i.e., ± 0.2 inch). Measurements indicated permanent deflections slightly greater than 0.2 inches were measured within areas under direct tire loading.

As can be seen in Rows 3 and 4 (Figures 17 and 18), no discernable pattern of movement could be detected and almost all measurements were within the tolerance of the survey. These two rows run perpendicular to the driving direction of the fire trucks (see Figure 14). Row 5 runs parallel to the driving direction and a pattern of deflection can be seen with a maximum deflection of 0.4 inches ± 0.2 inch (see Figure-19).

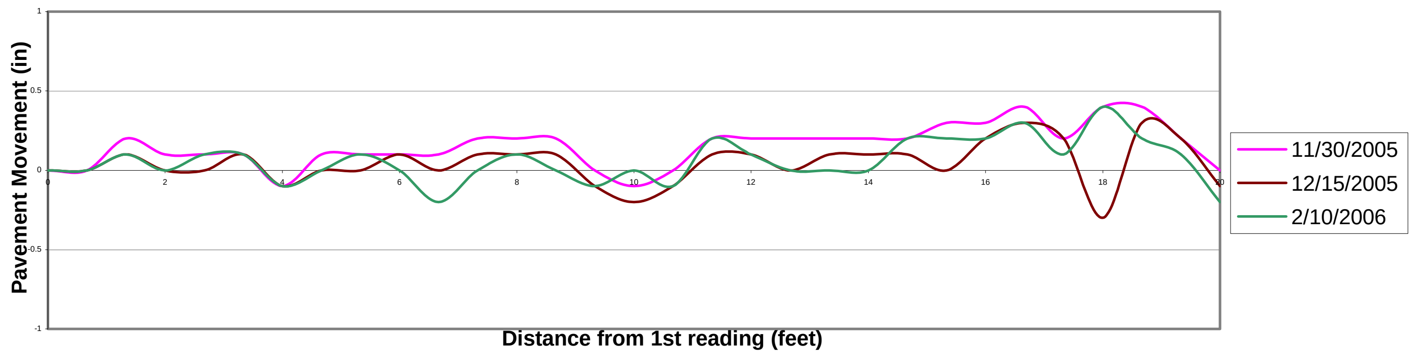

Figure-15: Manometer Readings
Row 1- Grass Seed Area

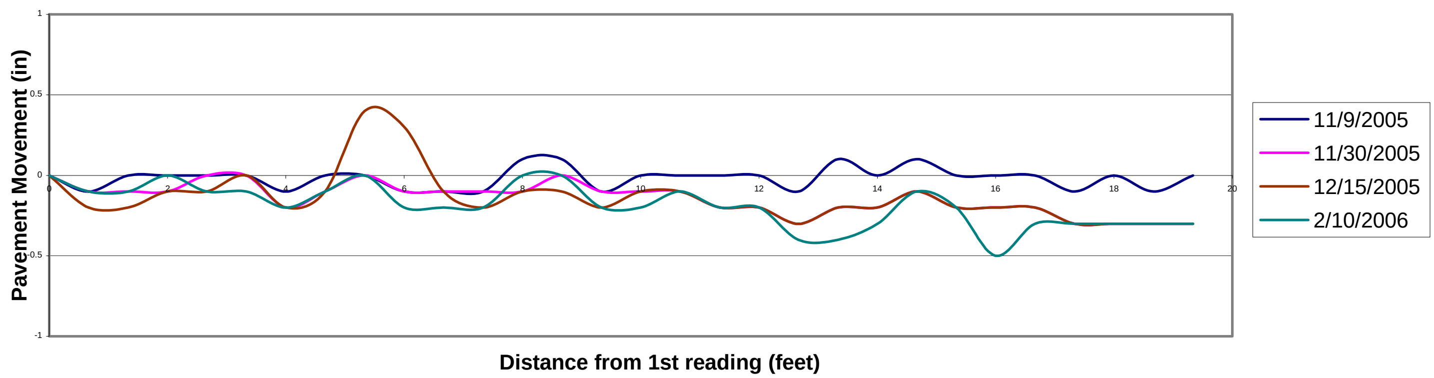

Figure-16: Manometer Readings
Row 2- Grass Sod Area

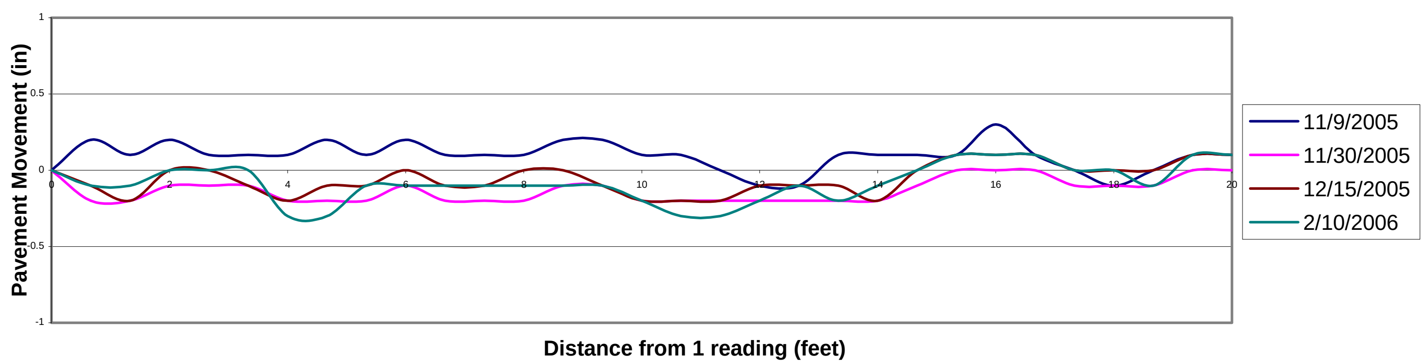

Figure-17: Manometer Readings
Row 3- Gravel/Cement Area

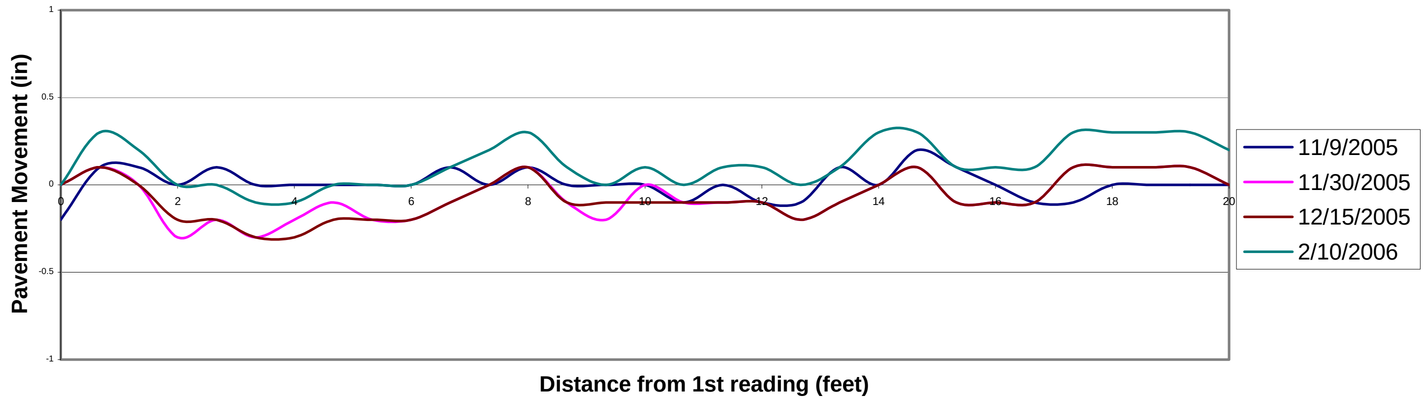

Figure-18: Manometer Readings
Row 4- Gravel/Cement Area

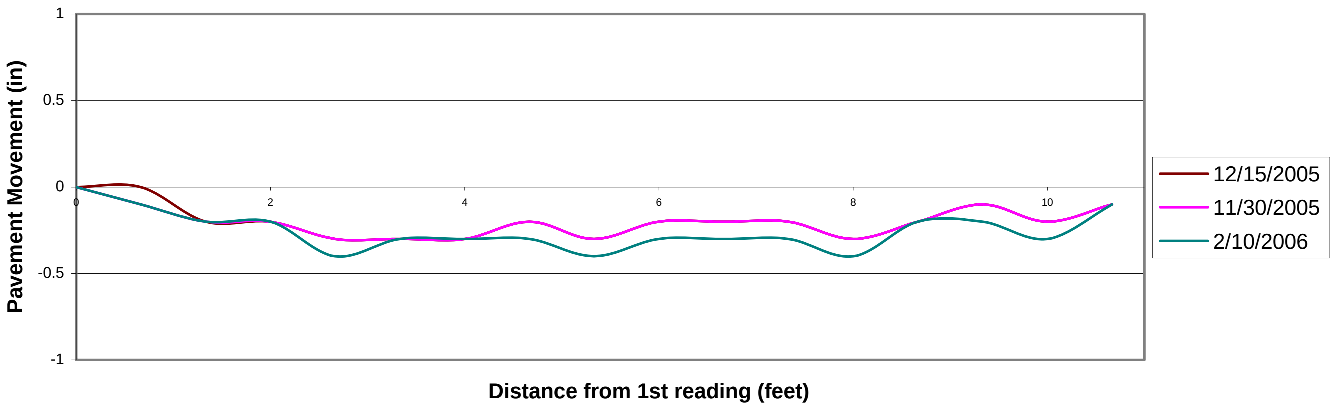

Figure-19: Manometer Readings
Row 5- Gravel/Cement Area

CONCLUSIONS

This study of Drivable Grass® has been able to quantitatively and qualitatively evaluate the performance of Drivable Grass® with repeat cycles of heavy vehicle loading. During the study, the Drivable Grass® system was subjected to a higher number of load frequency and/or higher loads than what would be expected over the service life of the product for typical uses. The study showed excellent results, which have been documented through the use of manometer surveys and photo documentation.

Drivable Grass® performed very well in regards to both tolerating minor subgrade deflections and structural performance. No cracks in the concrete muffins were found within any of the deflected subgrade areas. Unlike asphalt concrete or other hardscape surfaces, Drivable Grass® controls flexural movement within the control joint areas and did not result in topical cracking which would require maintenance to prolong service life. Comparison of the mat performance with different organic contents of the leveling layer have shown that there is no connection found between the two different leveling layers used and the permanent deflection of the paving system.

In this study, Drivable Grass® has demonstrated that this product is a viable option for all of the named typical uses while also being aesthetically pleasing.

Reference:

California Department of Transportation, Highway Design Manual, Section 600, Sacramento, 1995.