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VEHICULAR TURF

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Abstract. **Turfgrass in Florida is used for intermittent parking and driving of vehicles. In contrast to asphalt, turf provides environmental benefits: natural air conditioning, percolation, visual attraction, and flexibility for alternate use. This practice demonstrates the great utility of turfgrass, and violates the adage against walking on the grass. Dense, knitted turf roots bind sand, and improve traction resistance. Warm-season turfgrasses are comparatively wear tolerant, due to their reinforced vascular bundles. Unlike temperate areas, sand soils predominate in many parts of Florida, thus compaction problems can be minimal. Potential problems from traffic in turf in Florida are instability for heavy vehicles, need for appropriate grading and drainage design, and lack of motorist familiarity.**

"PLEASE DRIVE ON THE GRASS" is not the sign you expect to see, but why not? Florida turf areas are frequently walked on, driven on, parked on, and used for airport runways. Grass parking lots provide water percolation and natural air conditioning, but are often shunned in observance of the adage, "Don't walk on the grass." Although that might be a good rule for temperate areas, warm-season turfgrasses grown in sand tolerate formidable traffic.

The motive for grass parking areas may be economic, "Can't afford asphalt", or last-resort, "Don't have anywhere else to park", but the outcome is an environmental benefit. While high-impact turf areas can succeed by chance, some imaginative Florida designers, contractors, and clients have planned the concept into landscapes that really work.

Environmental benefits of turf parking were considered for Big Top Flea Market, Hillsborough County, Florida. The developer, Mr. Marvin Gill, undertook focus studies, indicating the importance of clean, convenient parking (Fig. 1, 2), and anticipating a pleasant atmosphere from natural turf. Prospective clients disliked a "vast expanse of asphalt," probably because of its discomforting heat. Construction challenges in the 2,500-space parking facility were solved by the right combination of people to make the concept work. Tampa Stadium (opened in 1967 with 10,000 parking spaces) and Joe Robbie Stadium (opened in 1987 with 15,000 parking spaces) are other examples of successful turf for parking. This trend throughout Florida includes churches, community colleges, and home lawns. Why should we drive on the grass?

Environmental Rationale

Asphalt and other nonevaporative surfaces absorb heat energy, dissipating it back to people by radiation and air convection. Because of its evaporative cooling, turfgrass reduces soil and adjacent air temperatures so we feel cooler. In one study in Missouri in October, turfgrass was near 38°C, compared with 60°C for asphalt (12). The daytime air conditioning from green vegetation is estimated by its evapotranspiration times the heat of vaporization (7), or 2.43 $kJ \cdot g^{-1}$ water at 30C. For turf in Miami transpiring an average 9.71 mm day^{-1} in August, this would be 6,500 $W \cdot h \cdot m^{-2} day^{-1}$, or 32,400 BTU per daytime hour for a 2.6 m X 6.7 m foot parking stall, while exposed to the sun.

Developments in Florida must provide for storm-water retention within their own boundaries. Special impoundments offset impervious areas, allowing percolation, but temporary ponds can occur. Standing water injures turfgrass and other plants, facilitating succession to sedges and other inadequately rooted species. Management of small wet areas is difficult and mosquito problems and other hazards can occur. Florida shopping malls sometimes use long, narrow, ditch-like catchments located betweeen parking ranges. These steep, often wet, areas are hazardous for people to cross, and they can become catchments for shopping carts and trash.

The vehicular turf alternative can increase groundwater recharge efficiency because trafficked areas are used simultaneously for percolation. This also makes it easier to satisfy building code requirements. Vehicular turf provides visually attractive up-close green areas, compatible

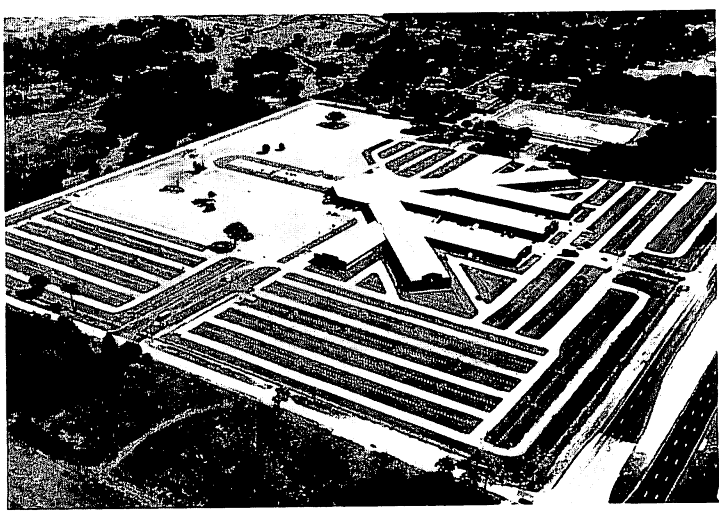

Fig. 1. Parking complex, Big Top Flea Market, Hillsborough County, Florida. Light-colored driveway aisles alternate with turfgrass parking ranges, which support an estimated 500,000 vehicle entries per year (200 per space per year). (Photograph courtesy of Mr. Marvin Gill).

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Fig. 2. Parking spaces at Big Top Flea Market are covered by irrigated, 'Argentine' bahiagrass, on sand, while driveway aisles are composed of a pervious, compacted, recycled concrete aggregate underlaid by geotextile fabric.

with softer, more personable architecture. A year-round growing season, such as that of southern Florida, allows vehicular turf to be always green and attractive. Vehicular turf provides visually attractive up-close green areas, compatible with softer, more personable architecture. A year-round growing season, such as that of southern Florida, allows vehicular turf to be always green and attractive. Vehicular turf provides valuable alternative uses, present and future. Examples are garage sales, outdoor food festivals, dances, sporting events, camping, and carnivals.

Wear

Turfgrass wear is above-ground damage caused by frictional abrasion, crushing, and shearing. Poor traction and wheel slippage ("spinning out") worsen abrasion. Vehicles as light as golf cars can be quite damaging (5), especially when the turf is wet. Abrasion may be exacerbated by poor turfgrass cover and the clinging of soil particles to tires, acting as a scouring agent. The importance of leaf abrasion has been minimized by some researchers. This is plausible "from the survival of grass and weeds growing in cracks of city sidewalks" (14). Leaf abrasion is repaired quickly because turfgrasses extend new leaves from intercalary meristems, but stolon abrasion is a long-term injury. Crushing damage occurs following traffic on wilted turf, and is typified by rapid discoloration.

Turfgrass wear tolerance is derived from cell wall components (9) which occur in greater amount in warm-season, C_4, grasses. As would be expected, C_4 grasses are more tolerant to wear than C_3 grasses (15). Among Florida grasses, bahiagrass (*Paspalum notatum* Flügge) is generally regarded as the best in wear tolerance, as well as being high in root strength. Because they have strictly above-ground stems, stoloniferous grasses such as St. Augustinegrass (*Stenotaphrum secundatum* [Walt.] Kuntze) and centipede grass (*Eremochloa ophiuroides* [Munro] Hack.) are more susceptible to abrasion and crushing than rhizomatous species such as zoysiagrass (*Zoysia* spp.) and bermudagrass (*Cynodon* spp.) Total verdure (above ground biomass) is also important in wear tolerance (9) and simply raising the mowing height can increase wear tolerance (15).

Recuperation is as important as direct wear tolerance. Because of its slow growth rate, zoysiagrass recuperates poorly from traffic damage (15), while bermudagrass recuperates quickly. Factors which promote fast growth and root initiation encourage recuperation. Potassium fertilization has not yielded consistent results. Recuperative differences party explain the greater severity of traffic damage in shaded areas (2), where recuperation is minimal. For this reason, shade tolerant species such as St. Augustinegrass, particularly dwarf St. Augustinegrass, may have a place in shaded, lightly trafficked areas.

Compaction and Stability

Compaction, the antagonist of percolation, has been studied with artificial simulations. Foot and wheel traffic press together fine soil particles, crush soil aggregates, reducing pore space. This is indirectly harmful to turf because pore space is necessary for movement of water and oxygen to roots. If at least 70% sand is present, compaction is less serious, and an acceptable percolation rate is sustained in bare soil (11). Percolation is greatly decreased once vegetation has been established, thus probably no more than 3% clay is appropriate (4). Medium sands (0.25 to 0.50 mm particle diameter) provide minimally adequate (up to 15%) water availability, and good drainage (3). Mechanical aeration is effective to open up compacted soils. Most native Florida soils are sandy marine sediments not subject to compaction problems, but may provide insufficient vehicular stability.

Surface stability of sand is weak because sand particles have little cohesion and little surface traction, although cohesion is improved at or near field capacity (6). Compaction by linear wheel movement or pressure rolling of wet sand actually increases the cohesion of sand, and is beneficial. Grasses quickly increase soil shear resistance because of their roots (13). Root organic matter is the main determinant of surface traction in sand, and above-ground plant material *per se* is reportedly not so important (6). This must be qualified, because above-ground biomass contributes indirectly to root growth. Turf which is worn above-ground (reduced verdure) may be unable to replenish root biomass.

The shearing action of turning wheels is a serious potential problem for vehicular turf (5). As the tires turn, they exert a high friction coefficient against the ground, which contributes to shearing. Slow moving turns and power-assisted wheel turns on stationary vehicles also stretch the ground in opposite directions, contributing to shear. Turfgrass leaves can thereby be broken or ripped from the stem, and the shearing often extends into the soil, ripping the roots. Loose, unconsolidated soil, such as dry sand, slips and shears more than strong soil. If this process continues beyond the capacity for root recovery, accelerated failure will lead to vehicles getting stuck.

The Human Component

While wear, compaction, and physical stability are the most important problems in vehicular turf areas, other potential problems occur and can be solved. Catalytic converters on low-clearance vehicles occasionally kill the grass, and may necessitate higher soil moisture before an event. Petroleum leaks from vehicles may be damaging, if vehicles park repeatedly in the same spot. Sprinkler heads and other utilities (e.g., valve boxes) which cannot be located away from trafficked areas must be set very close to grade, and safely reinforced, or else they will be damaged.

A psychological problem with grass parking areas is that motorists don't know where to park, resulting in erratic parking patterns and traffic jams. For infrequent events involving unfamiliar guests, human parking guides are essential. For other situations, clear signage may suffice, especially if it is supplemented by familiar visual cues, such as topography, bollards, and shrubbery. Turf presents a challenge to the human wardrobe. Narrow heals can puncture the surface or snag on grass stolons or subsurface debris. Smooth-soled shoes can slip on wet grass. Moisture, soil particles, plant materials (e.g., seeds), and insects may be collected on shoes or other apparel and carried into buildings. Maintenance of adequate turf cover is the best prevention, but it is also desirable to provide a passive method for cleaning of footwear in the entryways to buildings. There is probably no transportation surface that has been used more widely by more humans for more millennia than grass, yet it requires reacquaintance. This is another opportunity for improved signage and public relations.

Design Alternatives

Design for vehicular turf requires partial sacrifice of soil agronomic qualities, and percolation benefits, in order to achieve suitable engineering benefits in traction and resistance to shear. Knowledge of the type, frequency, and distribution of vehicular traffic is important in knowing how this can be accomplished. For buses and other very heavy vehicles, and daily automobile use, it is possible that no grass-only system would be suitable. For moderate weekend passenger car activity (e.g., more than two or three usages per week), asphalt or exposed, compacted rock are commonly used in the driveway alleys, but grassed sands are used for the parking ranges. This is the most common system used (e.g., Tampa Stadium and Joe Robbie Stadium).

Big Top Flea Market used permeable recycled concrete aggregate for the driveway alleys, to further increase total percolation. The aggregate was laid on a geotextile material to provide enhanced stability. For light weekend traffic (average of no more than one usage per week), grassed sands appear to suffice for parking areas and driveway alleys, but not headers, aprons, nor entryways. Worship Center Baptist Church, Plantation, Florida, used 100% vehicular turf (Fig. 3). Compacted "limerock", 15 cm deep, was overlaid with 5 cm sand. The area was planted to a mixture of seed, but only 'Argentine' bahiagrass persists. The bahiagrass has held up well, and is free of weeds. A potential variation of this concept is to construct high-use driveway alleys with a compacted, impervious base covered by a thin layer of a sand rooting medium. To provide runoff, the driveways would be slightly crowned, while pervious parking aisles would have a slight swale to capture runoff and fine soil particles. The impervious base would provide a shallow, perched water table which would make moisture management difficult, but achievable, with separate zoning.

Fig. 3. Turfgrass parking area, Worship Center Baptist Church, Plantation, Florida. This 100% turfgrass area consists of 150 mm compacted base overlaid by 50 mm sand. Although planted to a seed mixture, only 'Argentine' bahiagrass predominates. Weeds are absent.

A variety of soil stabilizing materials have been tested, with varying success. The ultimate goal of such materials it to attain 100% permeable pavement, and 100% turfgrass canopy. While not reducing turf damage, polypropylene fibers (e.g., VHAF) are an effective backup for sports turf fields which will become severely worn (1). Such fibers can interfere with grass establishment. Grass-paver complexes (Fig. 4) can enhance ground cover and turfgrass quality for some weaker grasses, but reduce quality for the stronger grasses (10). Some energy-absorbing materials cause problems for pedestrians (14), and problems in warm-season turf establishment. For grass-paver systems to withstand heavy traffic, they must absorb and safely disperse energy. Materials might also be added to improve the cohesiveness of sand, while maintaining percolation. Candidates for testing include calcined clay (8) and/or gravel, incorporated with specially selected sand. Mechanical impedance to root growth would be unavoidable, but tolerated by some turfgrass species.

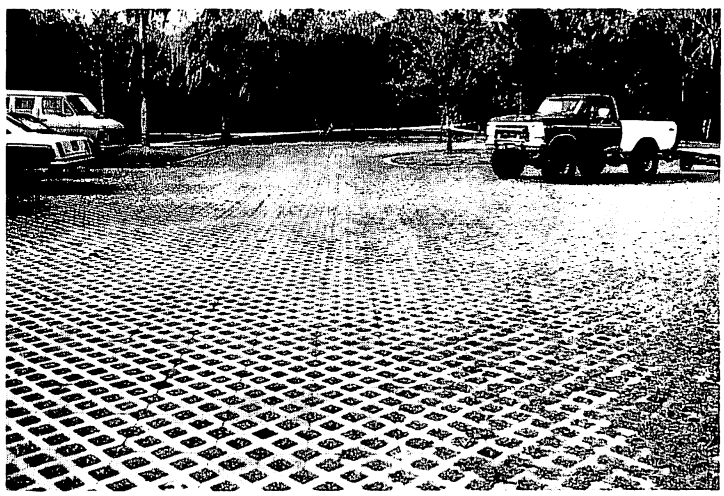

Fig. 4. Paver complex at Wilderness Park, Hillsborough County, Florida supports up to 30,000 vehicle entries per year (>500 per parking space per year). Composed of 'Turf Stone' planted to nonirrigated 'Argentine' bahiagrass.

Other design variations are needed for 100% turf parking areas. Larger radii should be planned for curves. The transition between natural turf and asphalt must be reinforced and feathered to withstand simultaneous energy sources (deceleration, turning, and change in elevation), which could result in separation of the edges.

Conclusions

Despite everyday successes of vehicular turf, and theoretical background, research is still needed to bring this concept to standard design specification. However, some generalizations are supported from experience. Light (two to three usages per parking space per week) parking is supported by turfgrasses in Florida, especially bahiagrass, on sand soil, but areas more heavily trafficked often need reinforcement. Grasses such as zoysiagrass which tolerate high mechanical impedance perform well in, or on top of, gravel and rock. Adequate irrigation must be available for turf parking. Tree shade is very detrimental to traffic tolerance, and it should be remembered that bahiagrass and bermudagrass are the least shade tolerant turf species in Florida.

Despite potential problems which occur from parking on the grass, the practice is widely successful. It is ironic that the immediate rationale for high impact turf is very often economic savings, not environmental. Vehicular turf distributes natural air conditioning to places where there are people, improves percolation to aquifers, and is enjoyed where it is used appropriately. If environmental benefits were more often considered first, designers might allocate the same resources for vehicular turf as for asphalt. Increased interest in alternatives could result in greater use of paver complexes, calcined clay, and other (as yet unperfected) materials, to make 100% turf a reality for public facilities throughout Florida. Because of their versatility, turf lots could provide overflow parking for shopping centers and other retail establishments. Compared with the asphalt alternative, many patrons would welcome the sight of a sea of grass.

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INFLUENCE OF PLANTING METHOD, FERTILITY PROGRAM, CULTIVAR, AND SOIL TYPE ON ST. AUGUSTINEGRASS

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Abstract. **Sod production of St. Augustinegrass, *Stenotaphrum secundatum* (Walt.) Kuntze, is gradually moving from organic muck soils in south Florida to mineral sand soils in central and north Florida. Central Florida also has many acres of reclaimed phosphate mined lands which may have potential for St. Augustinegrass sod production. This report summarizes studies of St. Augustinegrass growth on phosphatic clay and sand soils affected by methods of planting, fertility programs, and cultivars.**

Four-inch plugs planted on 1-foot centers on clay and sand was the best out of 16 vegetative planting methods evaluated. Stolonization was equal to plugs on clay but was the poorest planting method to use on sand soil. Apparently high inherent fertility in phosphatic clay soil negates need for supplemental fertilization after St. Augustinegrass establishment. Fertilization with seven different fertilizer carriers at different rates and frequencies affected only turf color but not

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