SUSTAINABLE PAVING SYSTEMS, LLC

GRASSCRETE - Molded Pulp Former Version Technical Bulletin

Grasscrete constructed with Molded Pulp Formers is a pervious concrete product available in a range of systems specific to the required use. Grasscrete is a cast-in-place rebar reinforced concrete slab containing a series of voids created by a patented forming process. These voids are subsequently filled with a variety of materials from decomposed granite only to sand and soil planted with a wide variety of vegetation. The Grasscrete system selected can be purely functional or can be a concealed product that is both functional and pleasing in appearance. Grasscrete offers the end-user the ability to provide year-round access for a variety of applications requiring structural paving surfaces without compromising the aesthetics of their exterior landscaping and having to utilize traditional hard pavements, minimizing the need to control storm water runoff.

Grasscrete constructed with Molded Pulp Formers can be employed as a stabilization product for areas that experience seasonal runoff or storm water channeling. Pervious installations requiring maximum water capacity, such as those over rainwater harvesters or crushed stone reservoirs, are excellent applications for the Grasscrete product cast using the Molded Pulp Former. Grasscrete can be customized to suit a wide variety of applications, including, but not limited to, the elimination of retention ponds or utilization of retaining areas, flood plain for overflow parking and the management of sediment buildup such as adjacent to large storm water inlets. Grasscrete does not contribute to the heat island effect like other hard surfaces such as asphalt and minimizes contaminant runoff during “first flush” rainfall into potentially fragile ecosystems. Trees and shrubs can be planted in close proximity due to the natural percolation of water to the root zone that would be restricted by a hard paving surface. Grasscrete is a very sustainable product that can employ a large recycled material content both in the form of aggregate and binder such as fly ash or slag—its lifespan is indefinite and can be recycled itself to form the aggregates for future Grasscrete applications.

The Molded Pulp Former utilized to create the void structure is constructed of 100% recycled paper products such as roll ends from newsprint, newspapers that were produced in excess of demand, paper packaging and any other clean products available. These paper products are added to water and agitated to form a paper pulp slurry that is vacuum-formed in a specialized mold. There are no hazardous additives that are utilized in the molded pulp production, with the main binding ingredient being simple starch. Molded Pulp Formers are designed for a single use with the strength to accept live concrete loads and workmen. Structural analysis contained in this document of the finished concrete section is based upon the bending moment of the steel reinforcement contained within the slab relative to slab depth, contact area with base and an assumed allowable ground bearing of 45kN/m2 for its base. By using combinations of base materials, concrete properties and different reinforcement types, the system can be tailored to provide the most applicable solution.

FEATURES AND BENEFITS:

- ***Structural Cast-In-Place System***
- ***Sustainable By Design***
- ***Very “Green” Product***
- ***Endless Potential Applications***
- ***Exceptional Durability and Strength***
- ***Many Void Fill Option***

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Design Principals

Construction

The Molded Pulp Formers are laid edge to edge over a 95% Standard Proctor compacted granular sub-base to form a continuous layer broken only by a 6" margin to the edge of each bay and at the point of each expansion joint rebar is then laid between the Molded Pulp Former tops on the integrally molded chairs which hold the reinforcement to the correct height.

For fully grassed or concealed installations, the concrete mix is designed to self-consolidate around the Molded Pulp Formers. Only when installing on the very steepest slopes is the slump markedly reduced to be sprayed as a shotcrete application. During pouring, the concrete is drawn level to the tops of the Formers by use of straight-blade squeegees. This should be the only finish required. Brushing is not required unless excess concrete is left on the Former top the finished surface is not required to be uniform in appearance and the final elevation is determined by the accuracy of the sub-base preparation. The application of soil and grass will even out the surface with any elevation corrections needed completed at that time.

For exposed installations such as parking lots, the concrete mix is designed to be poured around the Molded Pulp Formers at a 6-8 inch slump. Only when installing on the very steepest slopes is the slump markedly reduced to be sprayed as a shotcrete application. During pouring, the concrete is roller screeded just over the tops of the Formers. Once the concrete has reached adequate set it is generally broom finished. The finished surface is required to be fairly uniform in appearance and the final elevation is determined by the accuracy of the adjacent formwork. Tolerance typical to a functional concrete parking lot should be expected.

Consult SPS Technical Services or your local Grasscrete Distributor for more information on mix designs incorporating a high recycled content. Baseline mix designs are available to local ready-mix companies to assist them with the development of a workable mix based on local materials.

Once the concrete has set to the point where it will accept light foot traffic (usually later the same day or early the next), the top of the molded pulp former is mechanically broken open or depressed into the void.. Approximately 48 hours to several weeks after installation, the voids are in-filled with the appropriate product dependant upon the system.

FILL OPTIONS:

As a stone filled system: Typically, a clear single-sized stone, such as decomposed granite or washed river rock, with a nominal diameter of ¾" works well. We do not recommend the use of small-diameter rock, particularly the use of small-diameter pea gravel, which is easily displaced. The stone should be left slightly below the concrete tops to avoid being dislodged by plows or vehicles.

As a partially concealed application subject to continuous vehicle traffic: Sharp washed sand is best used to fill the first 2-3" of the voids followed by soil to within 1/2" of the concrete surface. Depending upon the environment in which the Grasscrete is being installed, a sand/soil blend for the entire void or soil only may be more appropriate options. The seed can be either blended with the soil or broadcast after the soil is in place. Leaving this recessed surface area will provide a reservoir for first flush runoff and avoid compaction of the root zone by the vehicle tires.

As a concealed application for periodic access: Sharp washed sand is best used to fill the first 4-5" of the voids, followed by soil flush with or slightly over the concrete surface if using rolled sod. If seeding, then an additional 1 ½" of soil over the concrete will be necessary. Depending upon the environment in which the Grasscrete is being installed, a sand/ soil blend for the entire void or soil only may be more appropriate options. The seed can be either blended with the soil or broadcast after the soil is in place.

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The use of a moisture-retaining admixture in the sharp sand is recommended to minimize the potential for burnout in dry conditions and to lessen the amount of irrigation if required. Polyacrylamide, or PAM, is a common soil admixture for this purpose—consult your local Grasscrete Distributor or a local horticulturist for recommended grass types, the use of soil admixtures, irrigation requirements in the project environment, etc. Additionally, for more decorative applications, a hardy ground cover such as elephant thyme or equivalent may be selected.

First trafficking of the surface should be linked to the curing period of the concrete. Under ambient conditions and a normal curing process, we would recommend the following guidelines:

After 24 hours:	Foot Traffic
After 7 Days:	40% of design load
After 14 Days:	75% of design load
After 28 Days:	100% of design load

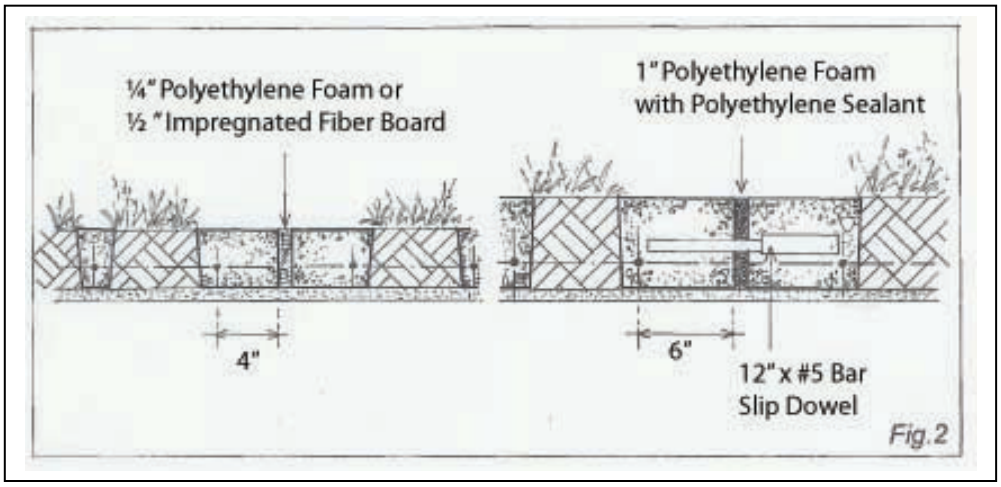
Where regular early use is required, we would recommend the incorporation of fiber reinforcement in the concrete mix to improve the concrete's resistance to early deformation or cracking.

Expansion joints are located at maximum 90-foot centers and can be specified in the two following types:

Type 1 – (fig.2)
Closed cell ¼"-wide polyethylene (PE) foam or ½" impregnated fiberboard

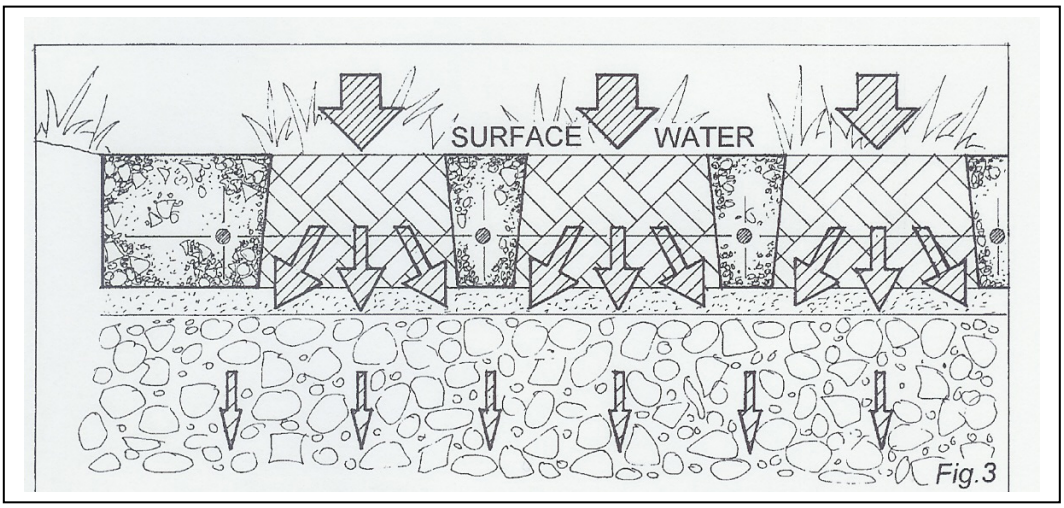
Type 2 – Heavy load transference (fig.2)
As Type 1 but incorporating 12"-long x # bar dowels at 24" centers with cap and de-bond to one end with joint sealed irrespective of filler type

For a Type 1 joint, we recommend a 4"-wide troweled margin to expansion joints. For Type 2 dowelled joints, this should be increased to 6".

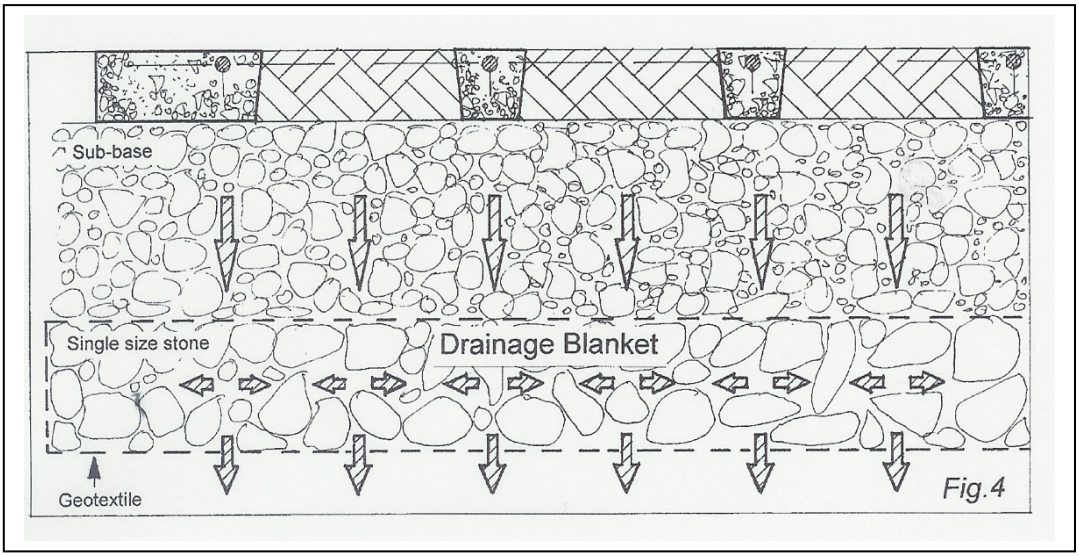


Sub-base Design
The sub-base material on which the Grasscrete is to be installed has a structural requirement of a 45kN/m2 allowable ground bearing. Where the existing ground naturally provides this, a well-graded granular layer of sub-base at a depth of 2-6" over the natural ground compacted to a 95% proctor is normally adequate. With that said, the storage capacity requirements of the specific system will determine the final thickness of the sub-base material and whether a clear layer of crushed stone is necessary rather than the graded material. The no fines sub-base should be a #57 stone, which will provide a void space volume of approximately 40%. To limit the possibility of "sub-grade pumping" through the sub-base under load, we recommend the utilization of an underlying geotextile layer where the sub-base is to be heavily trafficked.

Drainage
On level ground, fully concealed Grasscrete can drain at 90% the rate of ordinary grassland. In the early stages of grass germination, this figure may be slightly reduced until the root matrix is established. There may also be a natural raising of water table levels where significant site development has recently taken place.The shape of the Grasscrete void will enable the retention of surface water during periods where the sub-grade is slow to drain (see fig.3).



Where a slow draining sub-grade such as cohesive clay is encountered, consideration can be given to the utilization of an underlying drainage blanket as part of the overall sub-base design. This enables storage capacity to be formed without weakening the ground bearing capability (see fig.4).



Color Options
For Grasscrete applications where the concrete will be visible between the grass tufts or for those utilizing gravel as the void fill material leaving the tops of the cones exposed, the use of Integral Color may be desirable. Another technique that can be utilized with the exposed tops is to apply a topical stain or sealer.

Formwork Considerations
The system is designed to be capable of following most profiles either in the plan shape or vertical level. Consideration must be taken that the perimeter of the installation is determined by the fact that the formers are square. 45 degree or right angles are easily achievable, but curves will have a stepped back appearance. Typical gradation changes such as found with standard hardscapes applications are not an issue.

Penetrations
Openings for trees, hydrants, light-rail tracks, etc., can typically be taken into consideration with the use of 45 degree or right angle formwork and a 4"-wide troweled margin. Irrigation or electrical lines can come up through the cone tops by utilizing a sleeve to isolate the concrete from the conduit. Coordination of construction trades people for penetrations such as these is critical to the success of the installation.

Durability and Concrete Technology
Grasscrete Systems are engineered to provide long-term durability, low maintenance and structural strength. The Molded Pulp Formers and any associated products are factory-produced under strict quality control to provide consistent results for our Licensed Distributors and their customers.

Regularly Trafficked Areas
It is recommended to plant grass in the voids only to avoid compaction of the root zone over the concrete. The grass must be a long-bladed robust type and allowed to grow to a length that will help conceal the concrete if it was not installed with a decorative finish. This allows for continuous use at much higher speeds, tighter turning radii and for a much longer lifespan than other plastic ring or pre-cast products.

Infrequently Trafficked Areas
The principle types of use under this category are emergency access routes and road medians. A typical emergency access may be located around a high-rise building where the grass could be a finer variety but should take into consideration the potential for moisture loss to the concrete. The use of a Polyacrylimide (PAM) soil additive is typically adequate to provide enough moisture retention to support less robust grass types. Normally, the concrete ribs are concealed under a layer of topsoil adequate to retain the moisture required, as the Grasscrete in this circumstance is intended for periodic use and minimal maintenance.

Storm Channels/Storm Water Retaining
A number of different robust grass variations can be considered. The mix should generally provide good root anchorage to prevent pull out. In continuously waterborne conditions, the grass will be required to lay prostrate to create a protective thatch that performs a functional role. Such a mix will therefore call for a higher proportion of smooth stalked meadow grass. Maintenance of this type should be geared toward the period of maximum impounding in order to achieve the maximum thatching effect; the grass should be left long during the wet season.

Applications

Traffic Applications
A common feature of pre-cast or plastic unit systems is their susceptibility to settle under regular loading often rendering them unsuitable for all but the infrequently used areas. Grasscrete, however, places no reliance upon grass for stability—a drawback with other systems that require root growth in order for the product to perform as specified. .Grasscrete can therefore be specified in a wide range of applications. With a flat upper profile and a pocket shape designed to prevent tire intrusion, vehicles have little difficulty in using the surface. Tire vibration under use on large areas in particular can be uncomfortable and cause displacement of pre-cast units. With its reinforced structure, Grasscrete does not experience such problems.

Shrubs and trees form a softer, natural marker than do curbs or bollards and can be easily incorporated into most trafficked applications as delineation for vehicles. With its self-draining nature, Grasscrete can be cast to within 24" of mature trees.

i) General Access
Grasscrete is often specified for access routes required to have low ecological or visual intrusion. Its self-draining nature limits surface water runoff and enables roads to be constructed with minimal infrastructure work. Highways often require medians to be constructed, which are not for public parking but may be accessed by emergency vehicles, maintenance vehicles, emergency parking for disabled vehicles, etc. Periodic use, such as that for window washing equipment or maintenance vehicles, can be provided without compromising appearance or creating additional non-porous hard surfaces.

Another virtue lies in its "continuous slab" structure which defies vandalism, thereby making it ideal for use in prison establishments where an alternative pre-cast type could be lifted for inappropriate use.

A particular advantage over pre-cast concrete and plastic systems is the lack of differential settlement or surface shear under load. This eliminates the need for curb edge restraint and enables reduced sub-bases to be considered.

ii) Emergency Access
An emergency access road fulfils an essential function and should not be compromised in design by its possible infrequent use. Indeed, it is often the case that a fire access is much more regularly used than its designed intent. A common feature is the contractor's use of the surface for access during construction, window washing equipment or general maintenance. Under such circumstances, it is often subjected to much higher loads than a fire appliance would otherwise apply when utilized for an emergency only.

The point load is an important feature of platform use where, in the presence of saturated ground conditions, the equipment will be supported on jacking legs. Under such conditions, a paving layer of low tensile strength, such as a pre-cast or plastic system, is likely to be deformed into the sub-grade, causing a loss of stability (see fig.8). The most recent onsite performance testing takes into consideration equipment with a gross vehicle weight of up to 86,000 lbs. with a 105' boom containing 800 pounds in the basket extended 90 degrees.

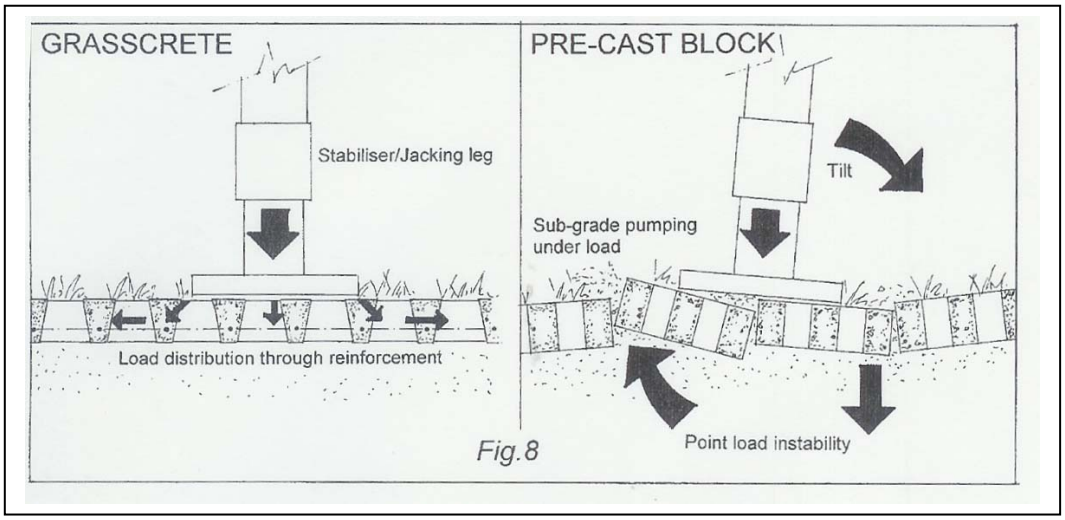


Fig.8

Another factor in the specification of a fire access route is the intended first use, particularly when considering possible temporary construction activity or routine maintenance requirements. Pre-cast concrete or plastic systems will generally require a full season's growth before a loading capability is achieved. This can often be a significant hurdle to overcome in the construction scheduling process. Grasscrete on the other hand can be used immediately once its initial curing period has completed.

iii) Pedestrian Use
It cannot be expected that a grass and concrete surface will be as easy to walk on as a solid pavement system, particularly for high-heel users. With that said, the Grasscrete system is probably the easiest grass reinforcement system to walk on. The same advantages that hold for vehicles apply equally to pedestrian use, the plan shape of the pocket allowing feet to sit predominantly on concrete. The optional use of bay divisions also aids the process of disembarking from vehicles where the first foot is placed on a solid concrete surface.

Erosion Control

Reservoir/Flood Control

A significant advantage in the specification of a pervious concrete product can be found in the venting of hydrostatic pressures in an earth slope. This enables much thinner paving sections to be utilized than would be required for "solid" paving.

The performance of steeper reinforced grass waterways has been studied at length in the CIRIA Report No. 16, which identifies a number of key elements to be considered in the design criteria for a suitable revetment.

From information provided, we can broadly categorize wear layers as follows:
LIGHTWEIGHT: Geotextiles/geog rids
INTERMEDIATE: Non-tied pre-cast concrete blocks
HEAVYWEIGHT: Cable tied pre-cast blocks and Grasscrete

Causes of failure under hydraulic load can be associated with one or more of the following factors:

- •Change of embankment profile, causing turbulent flow
- •Tail water jump at the base of spillways
- •Displacement of individual units by vandalism
- •Loss of grass cover where systems rely on grass for stability
- •Lack of an underlying geotextile layer

With the Grasscrete Molded Pulp Version continuously reinforced structure, an even upper surface is provided, which offers a consistent flow signature with no focal points for erosion. There is also no risk of vandalism to the surface and as such, maintenance inspections can be minimized.

With all waterborne applications, we would recommend the use of an underlying geotextile to prevent sub-grade scour in the event of a loss of soil filling to the individual pockets. It should be noted that with a continuously reinforced structure, the deadweight of the wear layer means that a relatively inexpensive geotextile can be utilized as opposed to the high flow variants required to prevent pre-cast units from lifting under hydrostatic pressure load (see fig. 10 for a typical reservoir cross-section).

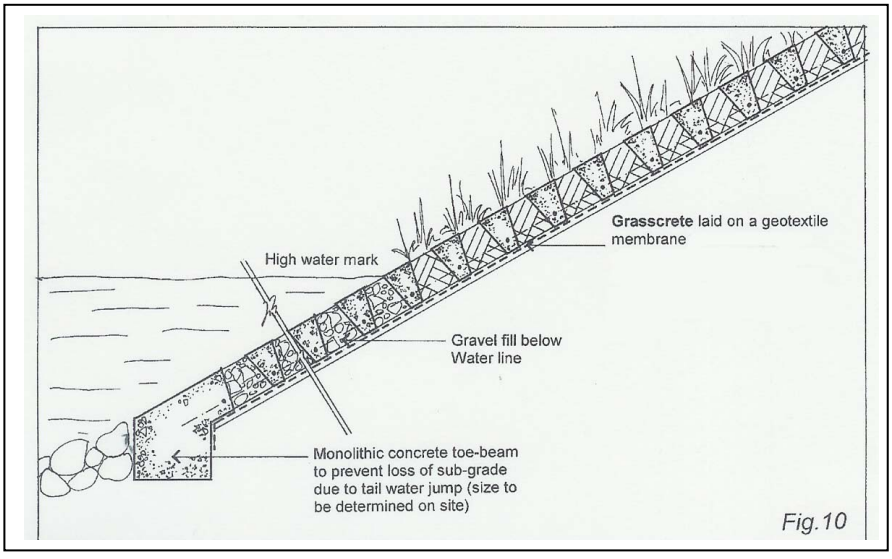


Fig.10

With its traffic-bearing capability, Grasscrete can be specified as a complete wear layer to reservoir berms with crest access for heavy vehicles being accommodated.

In environmentally sensitive areas such as salt flats, etc., the Grasscrete voids can be either sown with natural flora seed mixes or planted with indigenous rushes.

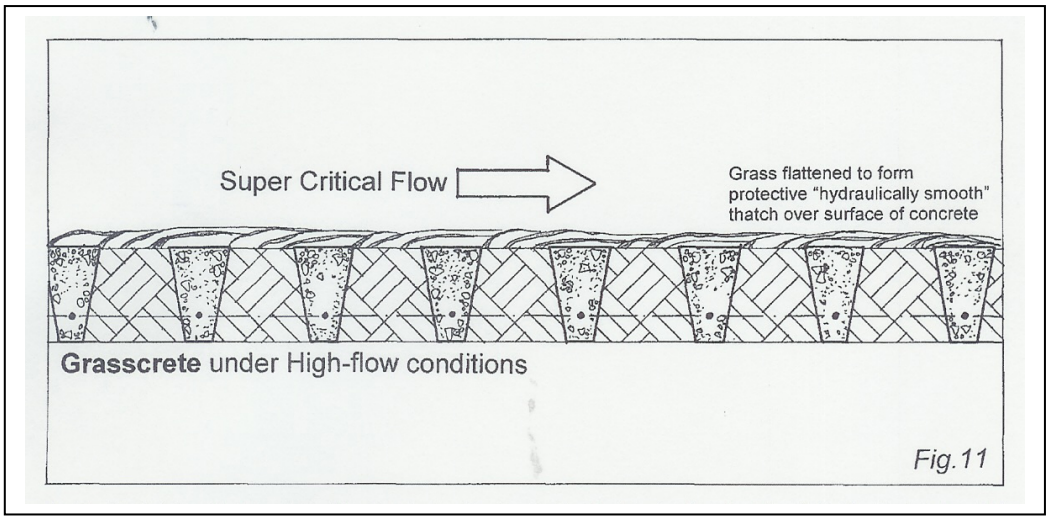
The Grasscrete cast-on-site process often suggests a limitation in the angle to which the system can be laid, with the notion of concrete loss during pouring. On the contrary, the shape of the plastic former is designed to limit the flow of live concrete, enabling slope angles of up to 45 degrees to be accommodated.

Storm Channels

Increasing urbanization makes increasing demands upon the process of controlling storm water runoff. Nowhere is this more evident than in tropical and sub-tropical climates where heavy rainfall leads to intense runoff and the specter of downstream flooding under inadequate control. It would be encouraging to think that the universal specification of porous paving systems will be a feature in years to come with the mitigation of runoff at source being the best possible cure. In the absence of this approach, there will continue to be a need to accommodate high volumes of storm water.

In temperate climates, the use of storm channels will tend to be associated with overflow channels for swollen rivers. In such circumstances, the wear layer will be designed according to the anticipated erosion, with maximum protection adjacent to the spillway or weir. In tropical or sub-tropical climates, the demands are much greater with a prolonged intense flow being encountered throughout the channel's length. To assist in the specialized design, please contact SPS Technical Services.

A principle design consideration in developing a channel section is the hydraulic roughness of the wear layer. The rougher the surface, the slower the flow, the greater the cross-section required. A common misconception is that a grassed surface will increase the hydraulic roughness in comparison to plain concrete. While it is true to say that a sub-critical flow will be slowed by grass stems, such a flow is not the determining factor in the design. By contrast, a super critical flow will result in a different situation occurring. Heavy impounding of grass stems will cause them to lay prostrate in a surface thatch, rather than being rougher than plain concrete (see fig.11).



A Grasscrete channel design can, therefore, provide the twin features of a natural grassed environment during dry season, low flow and a hardened wetland water course for peak-season demand.

Flow Rates

The Construction Industry Research and Information Association trials undertaken in 1986 were intended to assist in the production of a definitive guide for grass reinforcement systems. The subsequent guide—Report No. 16—was produced to create a benchmark for the hydraulic capabilities of available systems.

Under trial was our standard 5 1/2"-thick reinforced Grasscrete system, which was structurally unaffected by the maximum flow rate available to the trial. From the information provided, we have been able to interpolate the results into a recommendation of a capacity of 25 feet per second.

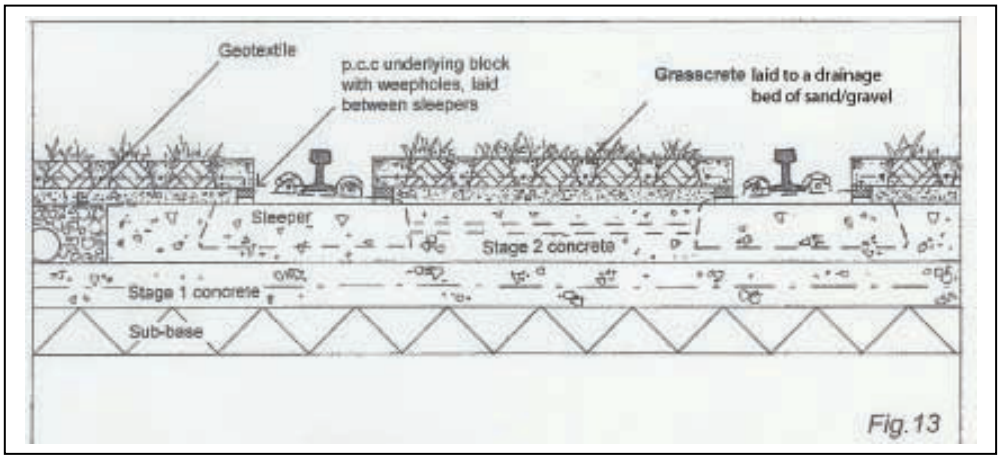
Custom Applications

Throughout the long history of Grasscrete, there have been numerous occasions for which the system has been called into use for previously unspecified roles. The unique adaptability of Grasscrete has enabled the product to rise to these new challenges, a few of which are detailed here.

1) Light-Rail Engineering

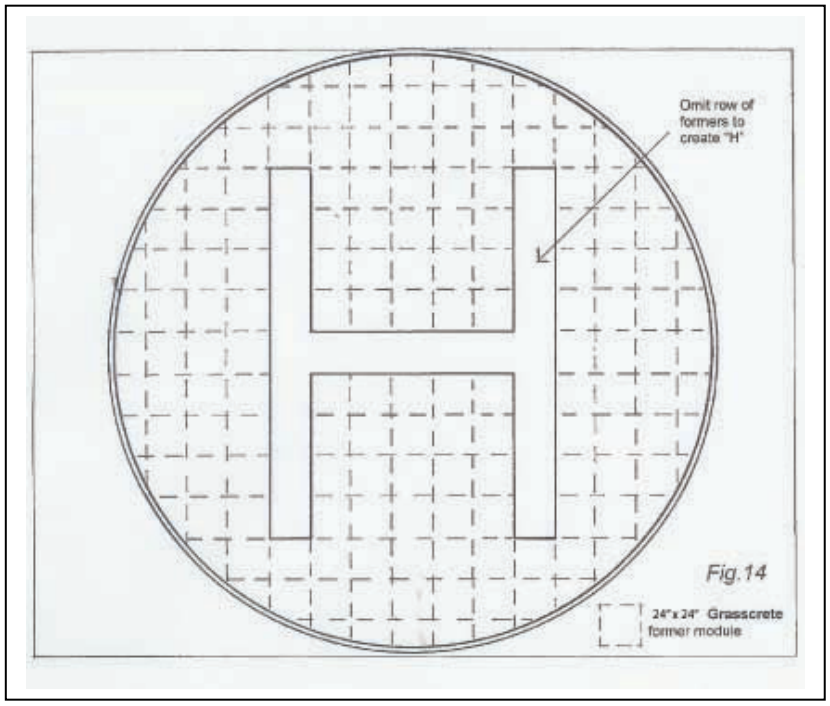
The ability to tone down the environmental impact of a light-rail network through city suburbs is compromised by the engineering considerations in the design. While a grassed track encourages an environmental solution, the following important factors must be considered:

- The potential for vandalism if pre-cast elements are used
- The need to provide access for maintenance vehicles
- Percolation of surface water when overlaying impervious stage 1 and 2 concrete bases (see fig. 13)
- A surface which requires little or no maintenance



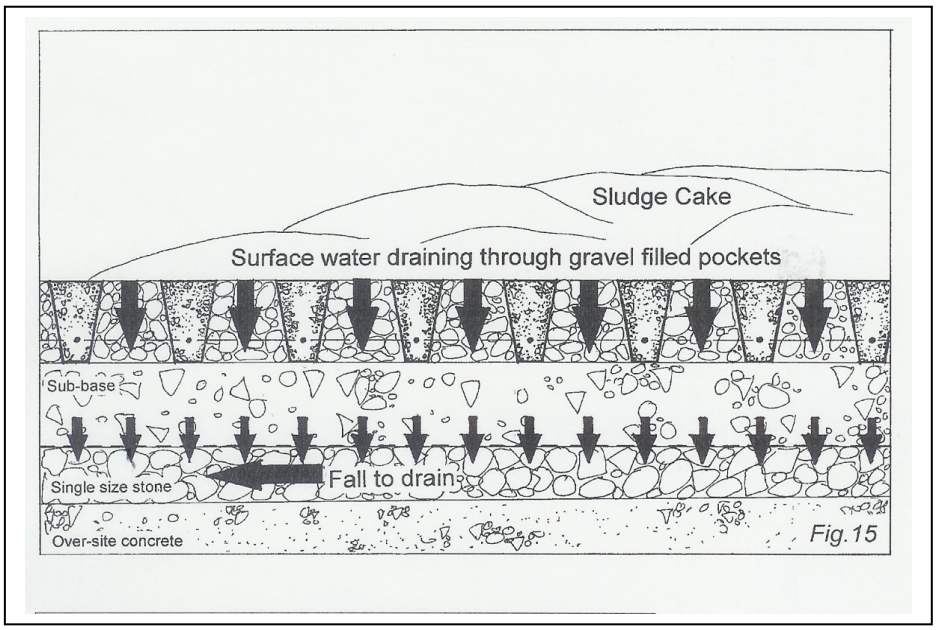
Helicopter Landing Pads

Using the essential criteria of a level stable surface and a natural grassed appearance, Grasscrete is the ideal solution to the provision of low-intrusion helipads. Further benefit is gained by forming the "H" monolithically within the surface by the elimination of the corresponding part sections of void former (see fig. 14).



Sludge Cake Drying

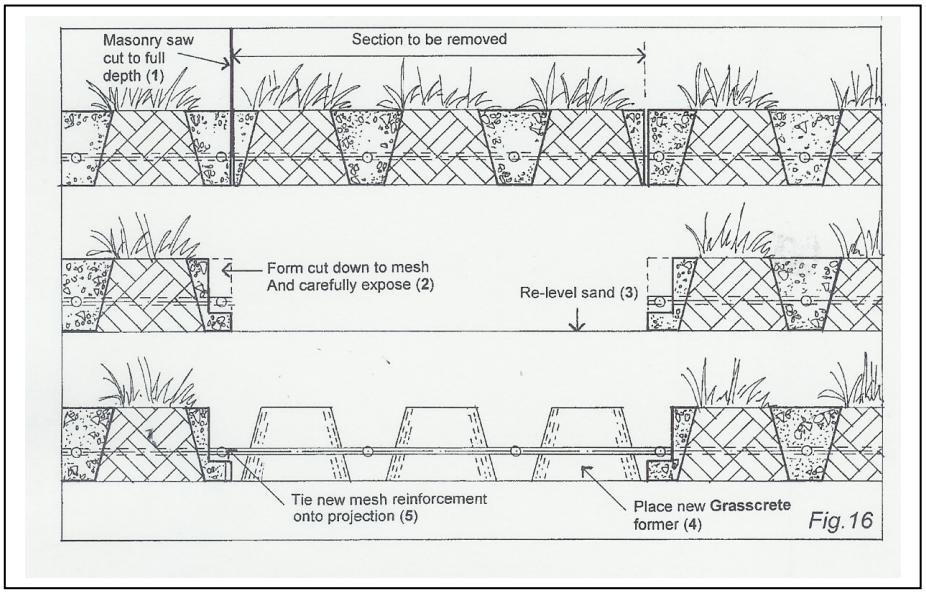
In this instance, Grasscrete was designed to act as a drainage slab for residual moisture contained within sludge removed from waste water treatment plants. Using a controlled filtration, the system allowed the sludge to dry prior to its removal for blending into screened topsoil (see fig.15).



Maintenance

Grasscrete is not a miracle system – it grows natural grass. The maintenance of Grasscrete is comparable to that of a grassed lawn. Regular vehicular use over a void-seeded-only application will trim the grass level down flush to the upper level of the concrete. In a typical parking application, the access routes may show a greater level of grass wear. It is advisable, therefore, to apply a routine maintenance schedule, particularly to the access locations.

Occasionally, it may be necessary to cut out sections of Grasscrete to allow, for example, a new service trench to be constructed. Occasionally, damage may occur due to inappropriate use. Under such circumstances, a remedial repair can be easily accommodated (see fig. 16).



Warranty

This product is warranted to be of uniform quality within manufacturing tolerances. Since control is not exercised over its use, no warranty, expressed or implied, is made as to the effects of such use. Seller and manufacturer obligations under this warranty shall be limited to refunding the purchase price of that portion of the material proven to be defective. The user assumes all other risks and liabilities resulting from use of this product.