Bomanite®

Your Single Source For Innovative Architectural Concrete Solutions

GRASSCRETE

Technical Bulletin

Grasscrete is a pervious pavement product available in a range of systems specific to the required use. Grasscrete is essentially a cellular reinforced concrete slab, the cells being voids created in the patented casting process which are subsequently filled with soil and seeded with grass or other appropriate ground cover. The Grasscrete system selected can either be purely functional or 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 with out compromising the aesthetics of their exterior landscaping and having to utilize traditional hard pavements, eliminating the need to control storm water runoff.

Grasscrete can also be employed as a stabilization product for areas that experience seasonal runoff, that require maximum water capacity to handle that such as off of an adjacent hard surface or that require a structural base material prior to application such as use under pre-cast unit porous paving systems. Grasscrete can be customized to suit a wide variety of applications where the elimination of retention ponds, swales or other storm water management devices is desired. Grasscrete does not contribute to the heat island effect like other hard surfaces such as asphalt, does not allow contaminants to runoff during "first flush" rainfall into potentially fragile ecosystems and allows for tree plantings in close proximity. 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 plastic former utilized to create the void structure is designed to have an indefinite number of re-uses, the strength to accept live concrete loads, and capable to being removed during the concrete plastic state to create the voids. Structural analysis contained in this document of the finished concrete section is based upon the bending moment of the mesh reinforcement contained within the slab, relatively 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 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 Options

Design Principles

Construction

US Standard 6"x6" wire mesh reinforcement is first laid over a 95% compacted granular sub-base. The 24"x24" plastic formers are laid edge to edge over the mesh in co-ordination with the voids of the formers to form a continuous layer broken only by a 4" margin to the edge of each bay and at the point of each expansion joint. The mesh is then elevated with chairs to the correct height.

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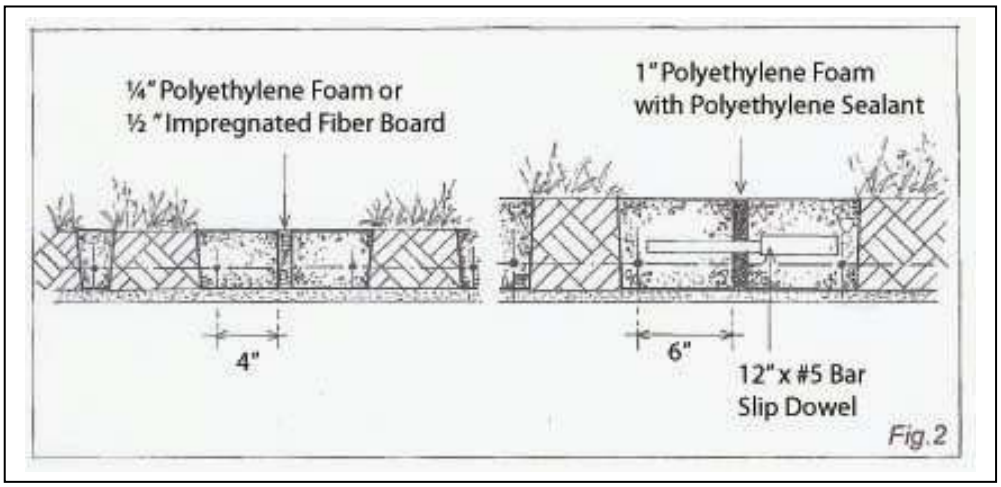
Expansion joints are located at maximum 30 foot centers and can be specified in the two following types:

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 #5 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".



The concrete mix is designed to self compact around the plastic formers. Only when installing on the very steepest slopes where the slump is markedly reduced should any form of compaction be considered. During pouring the concrete is drawn level to the tops of the formers by use of straight blade concrete rakes. This should be the only finish required. Brushing is not required unless excess concrete is left on the former top. In respect of tolerances, the depth of the concrete is limited by the depth of the plastic former. The level at the surface will therefore generally reflect that of the prepared sub-base.

Consult Bomanite Technical Services or your local Grasscrete Installer 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.

Approximately 48 hours after installation, the voids are in-filled with topsoil and then seeded. Consideration should be given to the potential settlement of the topsoil which should be allowed to naturally take place. The seed can therefore be incorporated within fine topsoil. Alternatively, where immediate use is required the soil levels can be topped up at a later stage after initially striking flush to the upper concrete level. Where gravel infill is used in lieu of topsoil/seed, we recommend the use of a #89 grading which will be less susceptible to displacement than smaller graded "pea gravel" types.

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.

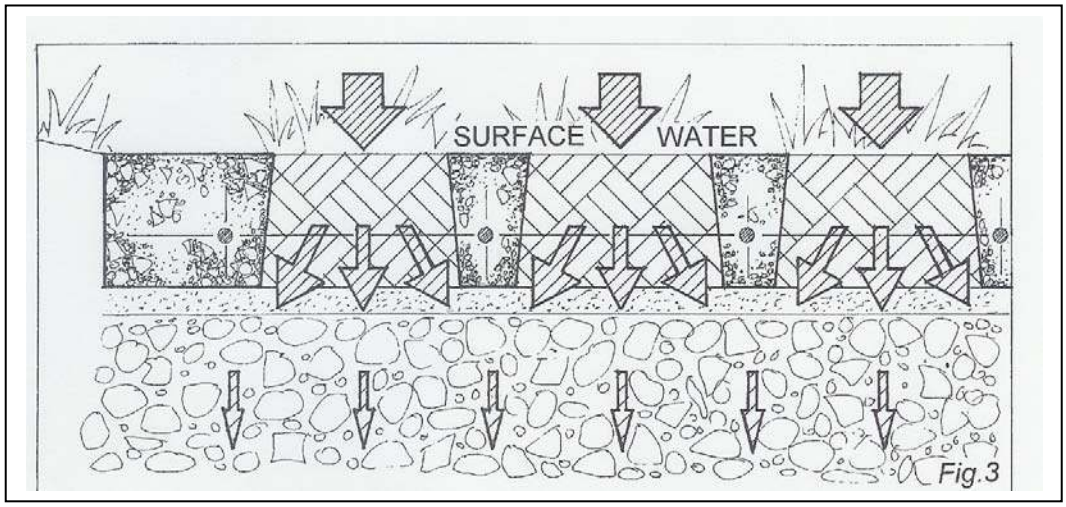
After 24 hours	Foot Traffic
After 7 Days	40% of design load*
After 14 Days	75% of design load*
After 28 Days	100% of design load*

Where regular early use is required we would recommend the incorporation of fiber reinforcement in the concrete mix to harden to the pocket walls.

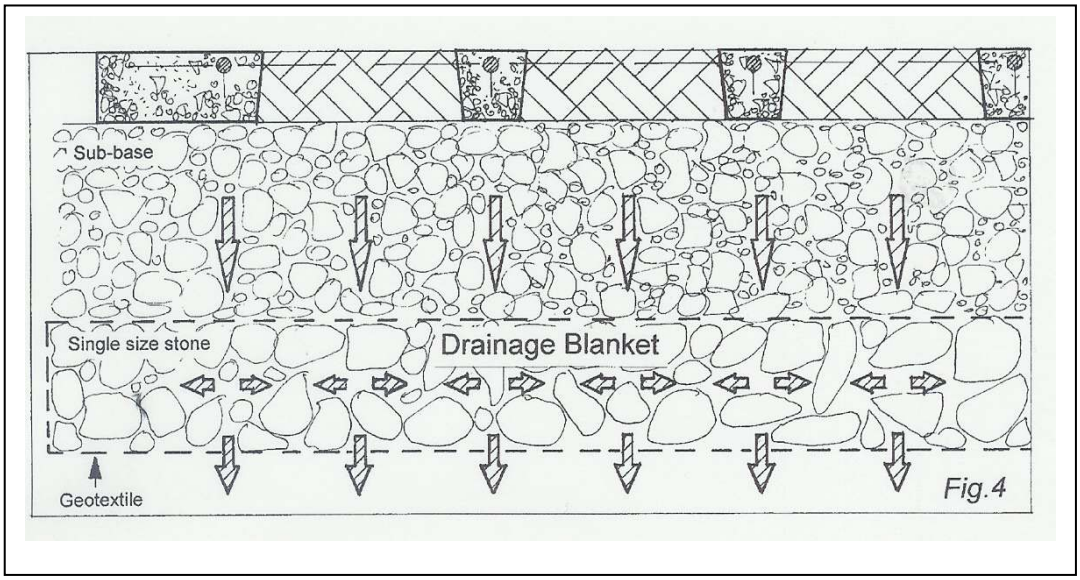
Earthworks and Sub-base Design
As stated previously, the base material the Grasscrete is to be installed on has a structural requirement of a 45kN/m2 allowable ground bearing. Where the existing ground naturally provides this, a sub-base depth of 6" is normally adequate. With this said, the storage capacity requirements of the specific system will determine the final thickness of the sub-base material. The sub-base should be a #57 stone granular sub-base with 95% minimum compaction. This will provide a void space volume of approximately 40%. If the Grasscrete utilizes a 100% granular fill for maximum permeability and to take up the storm runoff for its entire surface area plus additional non-porous surface area, then a calculation of storage capacity will be necessary. 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 typical seeded 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 those utilizing gravel as the void fill material leaving the tops of the cones exposed, the use of Bomanite Integral Color may be desirable. Another technique that can be utilized with the exposed tops is to apply a topical stain such as Bomanite Con-color, Chemical Stain or Color Cure sealer. Consult the Bomanite Technical Bulletins for additional information on these products.

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 24" x 24" 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. Co-ordination of construction trades people for penetrations such as these are critical to the success of the installation.

Durability and Concrete Technology
The Grasscrete Systems are engineered to provide long term durability, low maintenance and structural strength. The formers and any associated products are factory produced under strict quality control to provide consistent results for our franchise partners and their customers.

Grass Selection
The actual grass seed specification will depend upon the climatic location or intended use Grass types can be individually tailored for individual projects according to climate, use and aspect. Ground cover such as Elephant Thyme may be an option in some climates- be sure to consult a landscape specialist that is familiar with vegetation appropriate for the region the Grasscrete application is taking place in.

<u>Regularly Trafficked Areas</u>
Such applications are generally associated with car parks where the grass will be required to grow under aggressive wear conditions. Normally, the concrete ribs are required to be visible to provide a surface which is less likely to slurry under use. The combination of these two factors suggests the specification of a tough grass suited to local conditions.

<u>Infrequently Trafficked Areas</u>
The principle types of use under this category are fire access routes and road medians.
A typical fire 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 shaded areas. Normally the concrete ribs are concealed under a layer of topsoil and intended for periodic use and minimal maintenance.

<u>Embankment/Slope Protection</u>
A number of different variations upon a common theme can be considered. The mix should generally provide good root anchorage to prevent pull out. In waterborne slopes the grass will be required to perform a functional role. Our earlier chapters have described how a stemmed grass can form a protective thatch when laid prostate by heavy water flow. Such a mix will therefore call for a higher proportion of smooth stalked meadow grass. Maintenance of this type should be geared towards the period of maximum impounding, 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 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 pre-cast. It 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, a factor associated with pre-cast units, which on large areas in particular, can be uncomfortable and cause displacement of the pre-cast unit. With its reinforced structure Grasscrete does not suffer from such problems.
Shrubs and trees form a softer natural marker than 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 run off 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 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

A fire and 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. Under such circumstances it is often subjected to much higher loads than a fire appliance would otherwise apply.

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 system is likely to be deformed into the sub-grade causing a loss of stability (see fig.8). The current Grasscrete testing takes into consideration equipment with a gross vehicle weight of up to 66,000 lbs with a 100' boom extended 90 degrees.

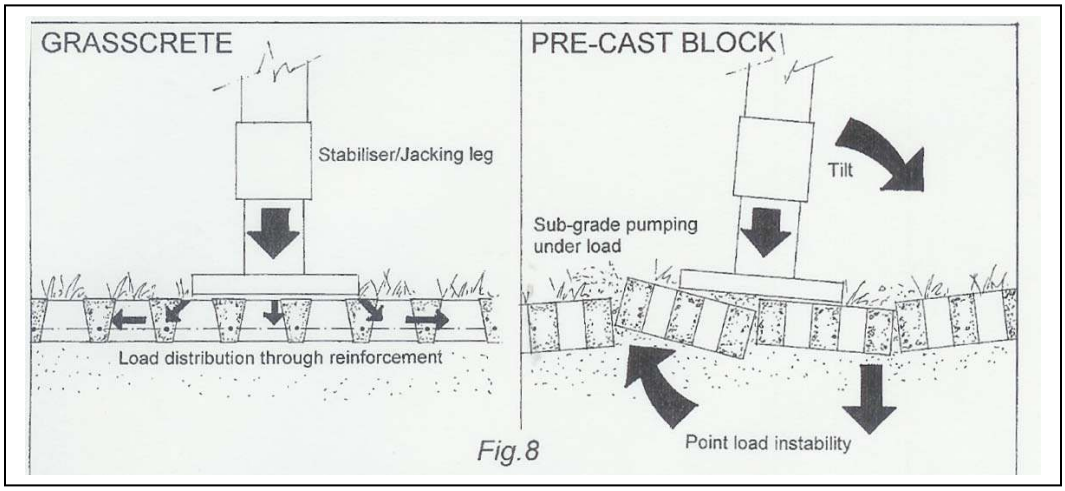


Fig.8

A further 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. 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 cellular revetment 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 16 which identifies a number of key elements to be considered in the design criteria for a suitable revetment.

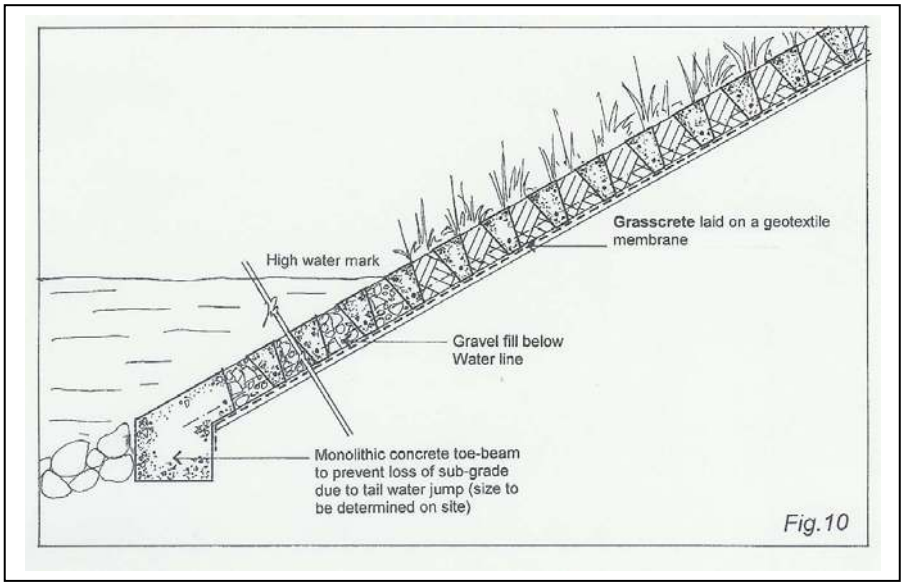
From information provided, we can broadly categorize wear layers as follows:
LIGHTWEIGHT – Geotextiles/geog rids
INTERMEDIATE – non-tied precast concrete blocks
HEAVYWEIGHT – cable tied precast blocks and GRASSCRETE

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 fro stability
-Lack of an underlying geotextile layer

With Grasscrete's 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. For a typical reservoir cross section (see 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.

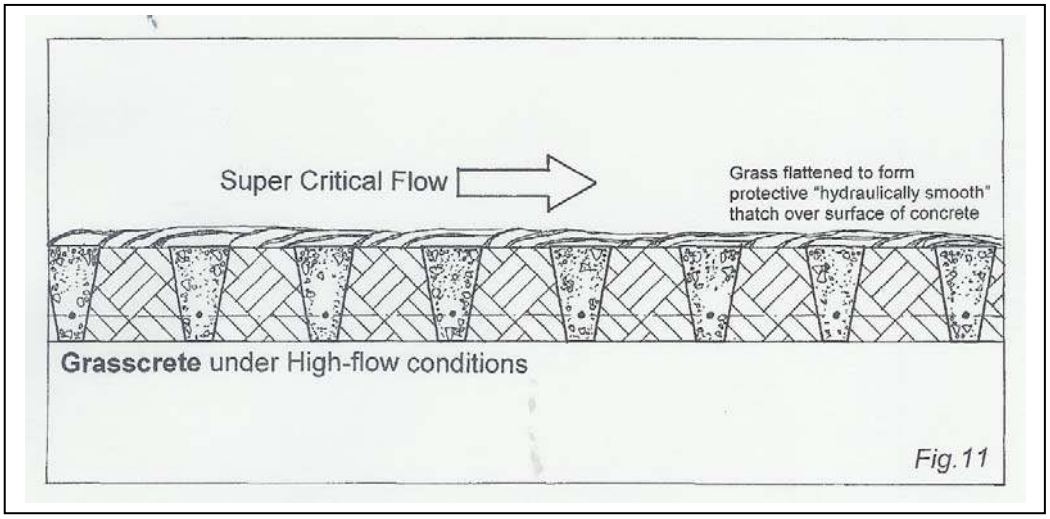
Grasscrete's cast on site process often suggests a limitation in the angle to which the system can be laid, with the notion of concrete loss during pouring. On the contrary, the shape of the plastic former is designed to limit the flow of live concrete enabling slope angles of up to 45' to be accommodated.

STORM CHANNELS

Increasing urbanization makes increasing demands upon the process of controlling storm water run off. Nowhere is this more evident than in tropical and sub-tropical climates where heavy rainfall leads to intense run off 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 run off 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 Bomanite 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. Whereas 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 see 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.

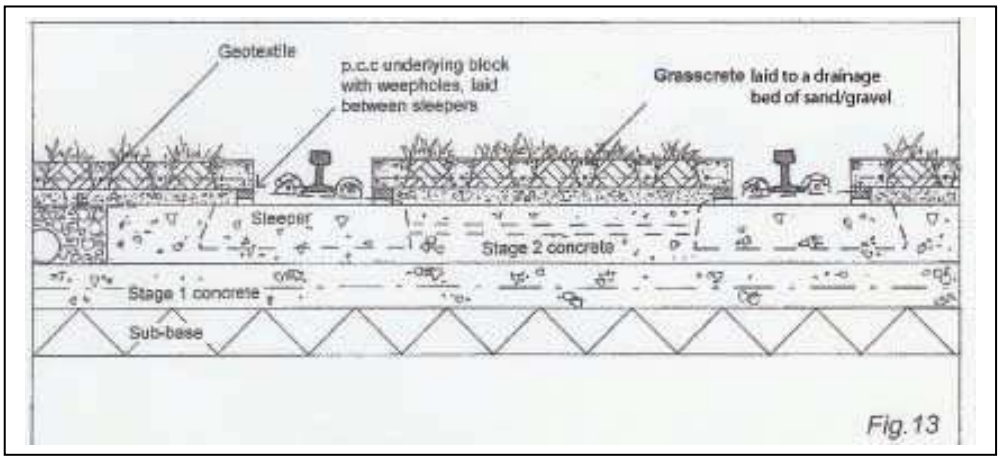
FLOW RATES
The Construction Industry Research and Information Association trials undertaken in 1986 were intended to assist in the production of a definitive guide for grass reinforcement systems. The subsequent guide Report No 16 was produced to create a benchmark for the hydraulic capabilities of available 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 Grasscrete's long history, there have been numerous occasions where the system has been called into use for previously unspecified roles. Grasscrete's unique adaptability has enabled the product to rise to these new challenges, a few of which are detailed here.

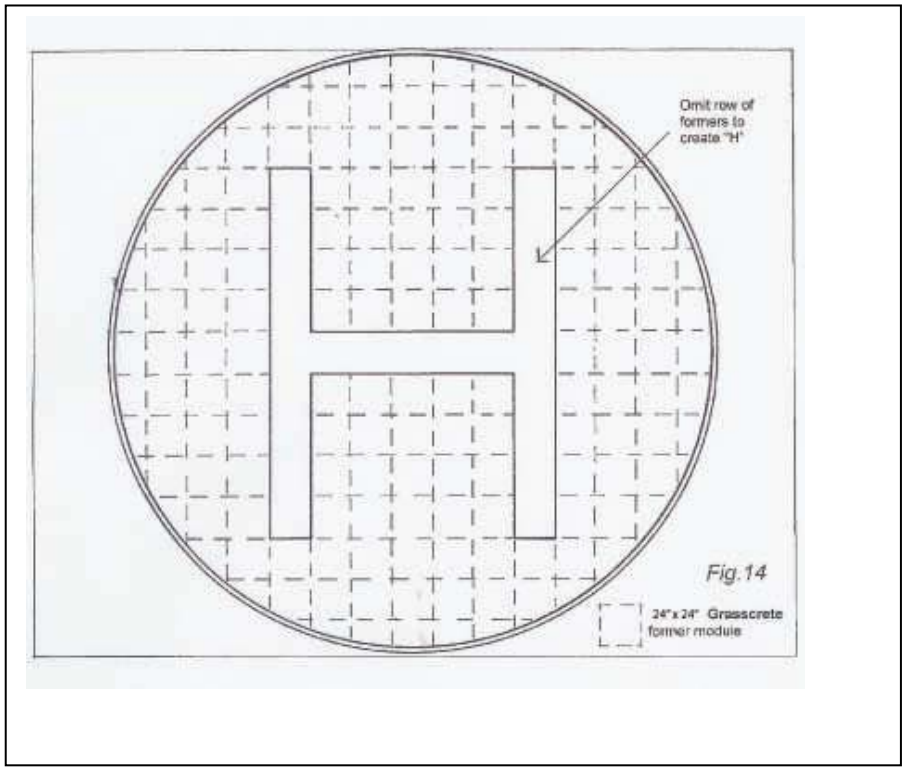
1) Light Rail Engineering
The ability to tone down the environmental impact of a light rail network through city suburbs is compromised by the engineering considerations in the design. Whilst a grassed track encourages an environmental solution, a number of important factors need to be considered.

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
A surface which requires little or no maintenance



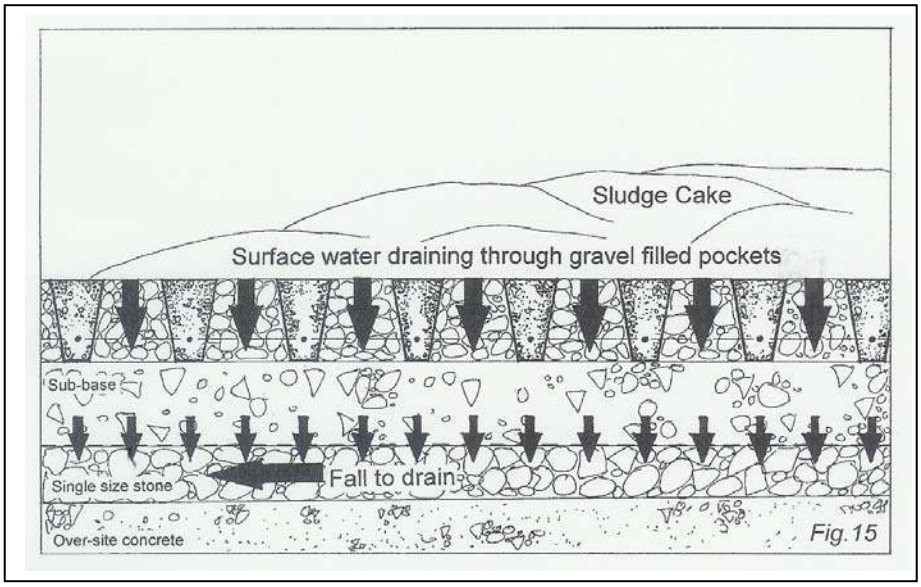
Helicopter Landing Pads

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).

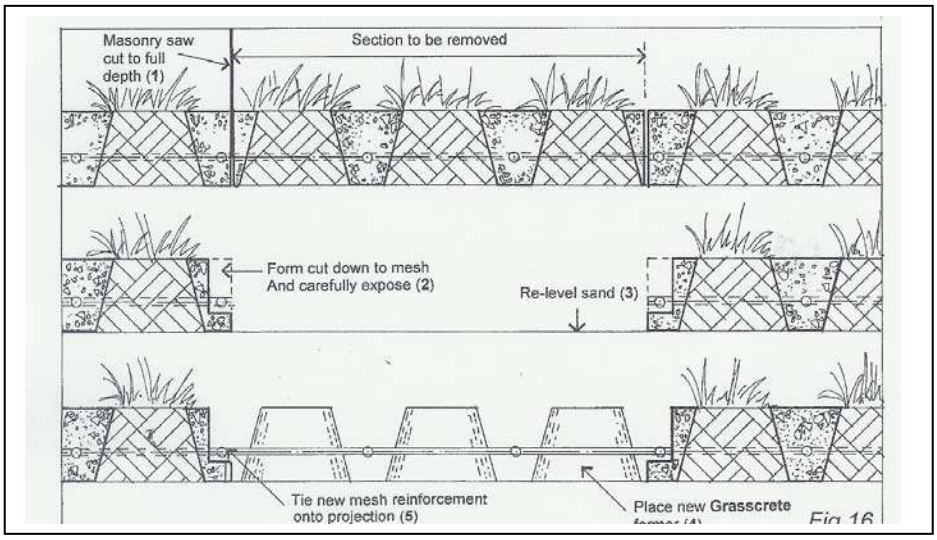


Maintenance

Grasscrete is not a miracle system – it grows natural grass. Just as a grassed lawn requires maintenance then so will Grasscrete albeit to a lesser degree. 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.

A simple maintenance schedule can be described as –
1. Routinely cut areas subjected to infrequent use to even out growth levels
2. Apply liquid based fertilizers as required -powder or granular fertilizers should be avoided due to potential for wind drift and build up on the concrete ribs which can result in scorching of the grass.
3. Regular trafficking may result in the soil levels falling slightly in the pockets. It is advisable to top up levels which are a potential trip hazard. Over filling should be avoided however as should compaction of the pocket fill which can injure grass growth.
4. After the construction of the pavement layer and if the surface is not to be used immediately, there is benefit to be gained from placing a fine layer of topsoil over the surface of the concrete. This will enable soil levels to be naturally replenished after settlement as well as providing a barrier against solar gain over the newly cast concrete.

Occasionally it may be necessary to cut out sections of Grasscrete to allow for example, a new service trench to be constructed. Very occasionally, damage may occur due to inappropriate use. Under such circumstances, a remedial repair can be easily accommodated as shown in 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.