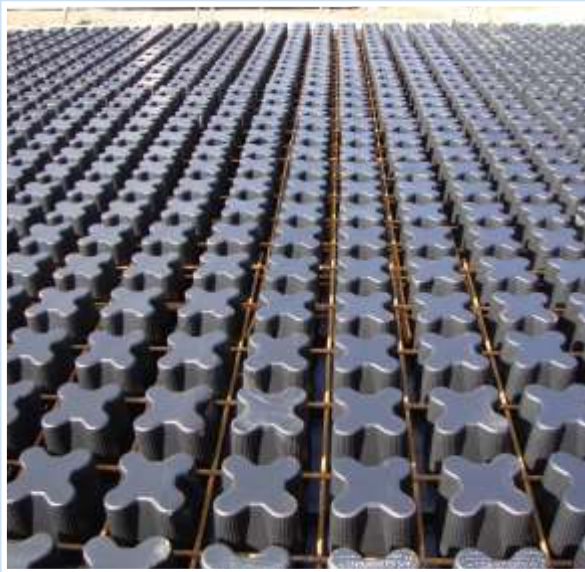


Grasscrete



Installation Guide



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OVERVIEW

What is Grasscrete?

Grasscrete is a cast-on-site cellular reinforced concrete paving system. With an engineered design it provides a certain level of capability, whether that be for traffic loading or water flow.

What isn't Grasscrete?

Grasscrete isn't a pre-cast concrete block or a plastic paver, neither of which can guarantee the same level of stand alone capability.

Grasscrete Applications

Grasscrete is installed across a wide range of applications, in differing sectors of both construction and landscaping, where its structural capability combines with its environmental credentials to provide sustainable engineered solutions. The *why's and wherefores* of design and construction are covered in our ***Grasscrete; Design Guide*** publication, this ***Grasscrete; Installation Guide*** focusses instead on the practical aspects of construction. Each chapter details the ground upward elements of construction with content in each case identifying the separate needs for **Traffic** and **Slope** works.



PREPARATION

At this stage and before we head into more detail, it's important to identify that Grasscrete alone won't make bad ground good, or uneven ground level. The relevance of this chapter shouldn't therefore be underplayed in the whole process of constructing a fully functioning Grasscrete installation.

Grasscrete is essentially a permeable paving system, to fully function, it will therefore require this process to continue through the underlying layers of preparation. When installing during dry months it's therefore important to consider how the area will differ during periods of intense rainfall. This type of information can be gathered from site investigation data, where bands of low permeability strata will be identified. In a less formal way, an indication of likely permeability can also be gained from the topology of the site and the type of native vegetation.

Trafficked areas

In addition to the design load requirements for the installation, consideration will also need to be given to the temporary load of construction plant and material deliveries. In the majority of installations the prepared sub-base will be subjected to short term heavy load and should be competent for this purpose, particularly during periods of inclement weather. For trafficked applications Grasscrete is designed with the provision of an allowable ground bearing of 45kN/m². Under normal circumstances the prepared sub-base should be able to support the load of vehicles such as fully laden concrete truck mixers with only minor deformation. Serious 'elephant tracking' of the surface would suggest instability either in the sub-base, the sub-grade or both.

In some contract forms the onus on responsibility for temporary works design is placed on the Contractor, who will be 'at risk' for any failure arising out of concentrated use during the construction period. It might be the case that the Contractor is therefore responsible for any additional depth of sub-base required to cope with the temporary works demand.

As part of the Contractor's temporary works assessment we recommend that site investigation information is sought to determine the suitability of the existing ground. In particular we recommend that the permeability is established as this can have a fundamental impact on being able to achieve consistency of bearing.

As a general guide the typical sub-base depths advised in the Grasscrete brochure can be achieved with a California Bearing Ratio (CBR) of 4% or greater. A lower reading would suggest the need to increase the depth of sub-base with possibly a need to introduce a drainage blanket layer if the earth is a clay material of low permeability. We recommend that this assessment is made in good time and in consideration of the likely worse case scenarios of a winter season, where conditions could be very different from those found during an earlier inspection.

The type of sub-base to be used should cater for the following:

- It should support the permanent load requirement of 45kN/m²
- It should support the construction load during the temporary works phase
- It should be permeable
- It should be frost resistant.
- It should be capable of fine levelling

The increasing specification of permeable paving systems is leading to suggestions of using low fines sub-bases, for UK applications these might be specified as a Clause 805 Type 3 granular material. Whilst this will inevitably achieve a good rate of permeability such materials can be problematic for grassed paving systems and can lead to the following problems.

- * Particles shifting under wheel movement during the temporary works, we refer to this as the ball bearing syndrome where the movement can cause a surface shear.
- * The likely loss of the sand blinding layer and the topsoil pocket fill through the voids within the sub-base. To counter this a specifier might call for the introduction of a geotextile membrane beneath the sand which significantly defeats the object and can lead to saturation of the sand and instability at the vital loading interface.

Where a Type 3 material is to be introduced, we recommend this to be positioned beneath a Type 1 sub-base as a drainage blanket layer, these two layers should be separated by a needle punched geotextile to maintain permeability whilst at the same time preventing the migration of particles through into the lower layer.

For the actual sub-base, we recommend the specification of a 40mm down graded material that for UK Applications would be referred to as a Clause 806 Type 1 material, this, if correctly installed should fulfil the requirements of both the temporary and permanent works phases.

For many projects there is likely to be a tolerance specified for the level of the prepared sub-base. Unfortunately it is often the case that in stipulating the tolerance insufficient consideration has been given to the Grasscrete installation. For a typical solid concrete paving layer the finished tolerance of the concrete can be independent from that of the sub-base, with the actual depth of the concrete being varied to make up the difference. With Grasscrete however the concrete is poured around void formers that have a controlled depth. Where the sub-base goes, then so shall the finished level as a mirror of that profile, as the sand blind at 20mm thick, is not intended to be a regulating layer.

To summarise therefore the shape of the sub-base will generally dictate the finished profile of the Grasscrete installation.

To provide load spread at the edge of an installation the sub-base should extend beyond the Grasscrete by an offset dimension that is not less than the depth of the Grasscrete.

Steep slopes

It is normal to expect that Grasscrete installations to steep slopes will not feature a sub-base, with instead the formation being a trimmed earth sub-grade. There a number of reasons for the omission of a sub-base :

- The hydraulic design might call for a natural earth sub-grade.
- In the absence of traffic in the permanent or temporary works there may be no requirement to upgrade the ground bearing capability of the formation.
- Cost
- It is generally not feasible to install granular sub-base layers to steep slopes due to difficulties in containing granular material and the potential to cause underlying slippage during compaction.

Earth trimming may involve the re-shaping of existing ground or the depositing and shaping of new capping layers, examples of the latter being often found in the water in the creation of water storage areas . The type of sub-grade will dictate when the final trim is undertaken relative to the Grasscrete installation. For a clay capping layer the project specification will often call for the material to be prevented from drying and to be finally trimmed immediately before the placement of the armour layer. Whatever the type of sub-grade, a common factor will be its influence on the finished levels of the Grasscrete and careful consideration should therefore be given to the preparation.

The shape of an earth formation might be dictated by the type of excavator , the nature of the sub-grade or the skill of the operator. What is certain however is that the following occurrences should be avoided or remedied prior to installing the Grasscrete:

- * Scalloping of the slope profile caused by the arc of the backhoe .
- * Excavator teeth marks or scour from stone dragging in the formation.
- * Loose surface material .

To eliminate these elements we would expect a need for a certain amount of hand trimming to the formation prior to the Grasscrete installation.

Where toe beams are to be installed, consideration should be given to the timing and extent of the trench excavation so as not to remove passive support at the base of the slope.

Geotextile membranes

There are a number of locations where the use of a geotextile might be considered in relationship to a grasscrete installation:

1. At the interface between the sub-grade and the granular sub-base. This is often an aid to preventing the sub-grade from being pumped back through the sub-base during temporary works loading, as it prevents the migration of fines. Care should be taken however to ensure that the selected geotextile enables the required rate of permeability to be maintained.
2. As a separation layer between the sub-base and an underlying 'drainage blanket' layer that normally consists of a no-fines granular material. Such a construction is often called into play where the underlying sub-grade has a low rate of permeability, or where there is a call for rainwater harvesting. In this location the geotextile is intended to prevent the migration of fines from the sub-base into the no-fines drainage blanket. It should however optimise the rate of permeability and so we would expect a needle-punched geotextile to be used to combine both hydraulic and cost efficiency.
3. In water flow situations a geotextile should be placed between the formation and the Grasscrete. This is intended to prevent underlying scour in the event that soil fill might be lost from the Grasscrete pockets due to either intense water impounding, or by seepage intrusion from adjacent ground. Advice should be sought from the design engineer as to which type of geotextile to use. Whatever the type selected it needs to take account of the following factors that will impact on the Grasscrete installation:
 - The geo-textile will require a dusting of sand placed over it to prevent it from being damaged during the subsequent melting of the Grasscrete void formers. The depth of this dusting will be largely dictated by the type of the underlying membrane but as this material is potentially sacrificial, we recommend that the depth is limited to a target maximum of 5mm.
 - The interface between the geo-textile, the sand dusting and the underside of the Grasscrete void former can be the source of movement in the formers during the concrete casting, if there is insufficient skin friction. To achieve sufficient skin friction we recommend that the type of geotextile be either a). a needle punched non-woven material with a 'felted' texture or b). if a high flow woven material is selected, that it should be an open mesh mon-filament material so as to provide a level of grip for both the sand dusting and the base of the void former.
 - The geo-textile should ideally have a thickness of between 1.5 and 2mm, this will enable the material to sit flat to the sub-grade, so avoiding the incidence of puckering to the fabric, that might in turn cause the Grasscrete formers to lift from their seating that could in turn lead to loss of concrete grout during placement and in extreme cases the lifting out of final position of the former.
 - The installation of the Grasscrete will call for access by the installers over the geo-textile, it should therefore provide a surface that is both slip and trip resistant.
 - When jointed along a slope the uppermost membrane should overlap the lowermost.

Sand blinding

Before moving on to the actual construction it is important to establish that the sand blinding layer isn't intended to regulate or re-tolerance the formation layer. With an optimum depth of just 20mm it cannot be expected to modify to any significant degree the tolerance that is in place for the sub-base.

The tolerance regime on a particular site will often be dictated by the type of application. As an example, for a highway project it might be expected that the levels will be tightly controlled, whereas a Landscape Architect might wish for a rolling 'natural look' to an installation. The end requirement will therefore largely dictate how the sand is levelled. Where consistent levels are called for it is normal to screed the sand in place, this can be undertaken by one of two methods:

1. By use of a screeding board drawn down from the top of the formwork or kerb, this might see the board being notched over the shutter to more easily control the process.
2. The placement on the sub-base of a tubular screeding rail, this will allow variable profiling to be established within the bay.

In each case the initial basic positioning of the sand can be undertaken by rake or by using the Grasscrete squeegee. For the example 2. above an experienced Grasscrete installer may also 'eye-in' the final sand placement using the squeegee alone.

The sand type should be of a relatively coarse grading, of a type commonly used for concrete manufacture, this will enable the following key requirements to be achieved:

- The through passage of surface water into the sub-base without liquification of the sand layer.
- The avoidance of volume change in the sand layer during saturation and drying cycles.
- Resistance to wind drift.
- The ability to resist disturbance by foot traffic, during positioning of the Grasscrete void formers.
- Significant resistance to wheel loads from concrete truck mixers such that a local tidying up of disturbance will be all that is required.

Formwork

With a 50% reduction in concrete volume compared to a solid concrete slab and with much of the live load from the concrete placement being dissipated by the void formers, there is a much reduced load on the formwork during casting. This enables a lightweight and flexible construction method to be adopted.

The normal depth edges the type of formwork can be steel road forms with flexible types used for kerbs. With this type care will need to be taken to ensure that the sub-base is levelled beyond the edge of the Grasscrete to provide a seating for the road form flange. It will also require sufficient working space to enable the pins to be located within the brackets and to drive home the wedge fasteners.

Another alternative preferred by our UK installation team is to use pre-soaked softwood boards, as shown in *Fig. 1*. These provide the benefit of a narrower working space and a greater degree of flexibility. For cold climates they also limit the potential for frost damage that can occur against an unprotected steel face of a road form. Unlike road forms a timber edge will not be lug connected to its neighbour and so we recommend that boards are connected together using either wood pattresses or proprietary metal timber connectors. Boards should be held in place by steel pins positioned to each face of the boards with the inner pins being removed before the edges are trowelled.

Once in place, the pins should have high visibility mushroom caps fixed to them to prevent fall injury or impact damage.



Fig. 1

Grasscrete void formers

The first requirement in the construction phase will be to take delivery of the formers. For less than full container loads (LCL) this will normally see them being shipped on pallets nested together in packs. A pallet size of 1200 x 1000 x 2000mm will normally accommodate the following quantities:

Grasscrete GC3, 76mm thick: 216m² (600 pieces)

Grasscrete GC1, 100mm thick: 216m² (600 pieces)

Grasscrete GC2, 150mm thick: 108m² (300 pieces)

For Full Container Loads (FCL) the formers will normally be shipped, loose packed and nested together. This enables the quantity to be maximised and can see the following full load capacities:

Grasscrete GC3, 76mm thick: 7200m² (12m container), 3600m² (6m container)

Grasscrete GC1, 100mm thick: 6300m² (12m container), 3150m² (6m container)

Grasscrete GC2, 150mm thick: 3600m² (12m container), 1800m² (6m container)

When unloading the formers it is important to place them as detailed in *Fig. 2*

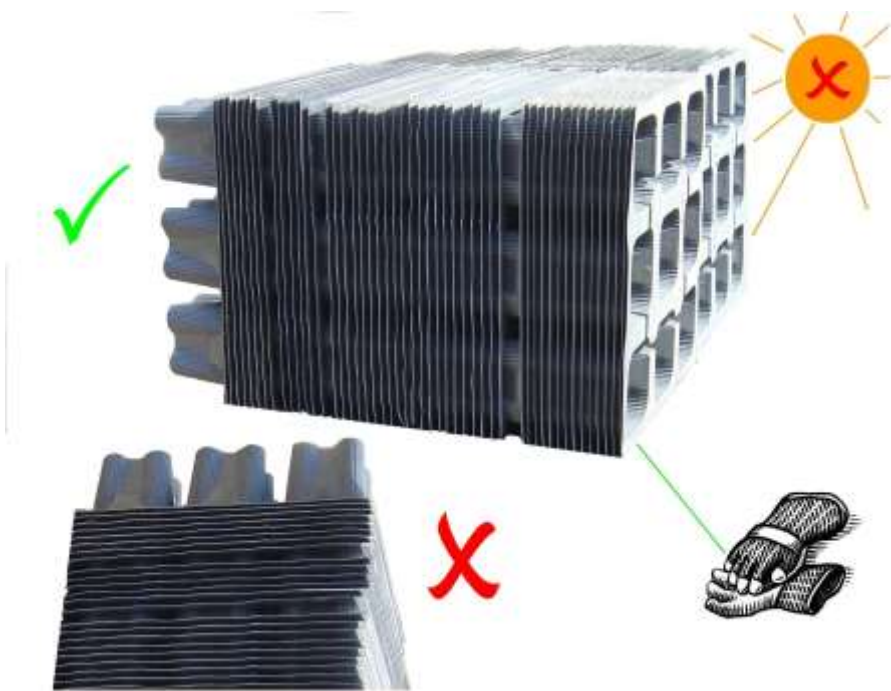


Fig. 2

Where formers are positioned either in a stockpile or in clusters adjacent to the works they should be weighted down to prevent uplift by strong winds. This is particularly relevant in locations such as airside installations to airfields, to avoid the risk of Foreign Object Debris (F.O.D). For this purpose the placement of either a tarpaulin or a sheet of mesh reinforcement over the stockpile is generally sufficient weight. The formers should be stored on level hard ground away from mud, which would need to be cleaned off each piece prior to concreting.

Each void former is coated with a patented anti-static slip agent then enables the formers to be both closely nested and then released. Aggressive handling is however likely to over-compress the nested packs and will lead to a more difficult process of separation. Under such circumstances the easiest means of separation is to usually :

1) Hold a nest of formers (<10 pieces) with the upstands facing downwards. 2) Grip the top former on two sides and shake in an up and down motion. At the same time push down with the backs of your fingers against the former immediately below.

Each former is manufactured from significantly re-cycled polystyrene as part of the Grass Concrete commitment to sustainability. Most of the re-cycled material will be of pre-consumer source and will have been graded according to the melt flow index required for the vacuum forming process. This process can mean variability in the colour of the former and can lead to some very occasional abnormalities in the moulding process. Any void formers that have blistering or transparency to the side walls should be rejected. At this same stage any formers that have been damaged during handling should also be assessed, in some cases dents can be pushed out enabling use, but in more extreme cases where the plastic has been damaged the former should be rejected. In some cases it might be possible to use the sound portion of these formers in locations where cut sections of formers are required.

Placement of formers

Once the formwork is erected and the sand blind positioned the next step is to place the Grasscrete void formers. Ahead of this the method of concrete placement should have been planned and this will dictate the starting point and process for laying out the formers. The variability of the process we describe later but in each case a number of basic principles should be adhered to:



Fig. 3

Fig. 3 identifies the formers being positioned with the lower most edge 100mm away from the face of the formwork, with the mesh reinforcement then cut back to provide a minimum 25mm end cover. The 100mm should be a minimum offset, so that where the actual width of the bay doesn't conform to the module then the edge width is increased to compensate. This is particularly important at changes of direction where the formers are stepped tangentially to the line of the formwork, as part of this process the 100mm minimum offset should be maintained.

The formers should be placed edge to edge in position across the bay but at this stage they do not need to be individually aligned. We do however recommend that the general levels of the formers are routinely checked by passing a single former along the underside of a string line drawn from edge to edge.

Each former has a 600 x 600mm plan dimension, and is further divided into 200 x 200mm pocket modules that relate to the same modular dimension of the mesh reinforcement. The plan layout of each bay can therefore be modified by cutting formers in 200mm increments and this is best achieved by cutting a group of formers nested together either with a hand panel saw or with a mechanical saw as shown in Fig. 4. When using 200mm wide offcuts we recommend that they are placed inboard within a bay so as to be restrained by neighbouring formers during concrete placement.



Fig. 4

Once the formers have been laid out the mesh reinforcement is then lowered down over the formers to sit on the chair spacers that are integrally moulded part of the void former. During this process a shaking of the mesh from side to side as shown in *Fig. 5* will cause the formers to self-centre to the wires of the reinforcement.



Fig. 5



Fig. 6

Mesh reinforcement

As shown in *Fig. 6* mesh should be lapped *square over square*, in this case the lap is adjacent to a gap left for the formation of a parking bay marker. There is generally no need to tie mesh sheets together unless wires have become twisted in the stockpile and in such cases it is generally better to hold the mesh down temporarily with a road form pin driven at an angle to tighten down onto the mesh as it drives into the sub-base. Alternatively where a more permanent fix is required this can be achieved by positioning a 7mm diameter wire staple over the intersection of the mesh and driving that down into the base. Best results are achieved with a 600mm long strip of wire that is tightly bent to create two legs of equal length.

When installing the 76mm thick system care should be taken to ensure that top cover is maintained to the reinforcement within the slimmer slab, particularly as lighter weight mesh sheets will be in use. For such applications there can be benefit in using the staples described above at mesh laps to prevent fly-ends of reinforcement from rising towards the surface.

The overall size of mesh reinforcement sheets will vary throughout the World, typically for the UK they are 4800 x 2400mm, but for larger projects or regular consumption it can be possible to have sheets manufactured to a size that drops straight into bays, eliminating in doing so end laps. This is particularly useful in car parks where a 4950 x 2400mm sheet can be used for 5.0m parking aisles and a 5950 x 2400mm sheet can be used for 6.0m access aisles. In other applications a 3950 x 2400mm sheet can drop into a 4.0m access road or for narrower roads the same size sheet would require cutting but would nevertheless reduce the offcut waste that would arise from using a 4800 x 2400m sheet.

Expansion joints

As with any form of concrete paving Grasscrete will require expansion joints. The fact that it is a cellular slab, might influence the rate of expansion by offering a cooling effect but this should not be considered as part of the design. Expansion will take place along the interstices of the slab and should be accommodated. Our standard recommendation is for maximum centres of 10.0m x 10.0m and in this respect it is important to stress that the two dimensions should be consistent so that for example a 5.0 x 20.0m layout would not be satisfactory, although it provided for the same 100m² surface area.

In normal circumstances it won't be feasible to cast to a 10.0m width and so the bays will be smaller with intermediate joints being formed as contraction joints. This is highlighted in *Fig. 7* where a configuration for a car park is shown that enables the joints to be positioned initially as temporary formwork.

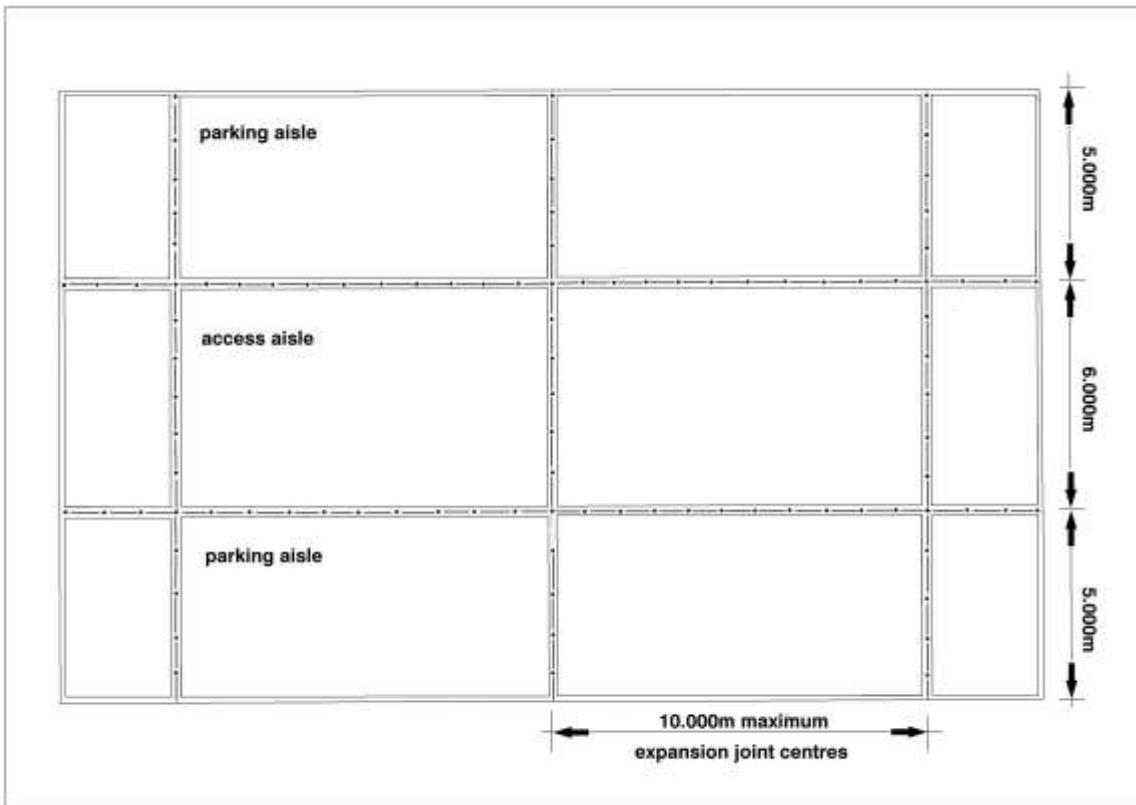


Fig. 7

For car parks where delineation is to be introduced the length of each bay can be reduced to 9.60m to match the overall dimension of 4 x 2.40m bays, as shown in *Fig. 8*.

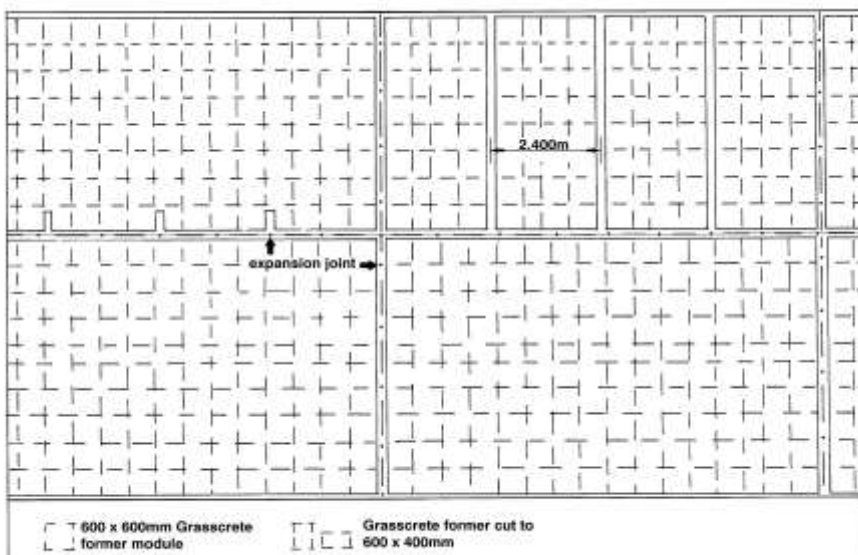


Fig. 8

600 x 600mm Grasscrete former module
 Grasscrete former cut to 600 x 400mm

The type of expansion joint filler may vary according to type of use and climate, but for Western European applications the default material is a 25mm wide softwood filler as shown in Fig.9.. This should be pre-soaked with water, to prevent bond adhesion to the concrete. This type of filler is sufficiently robust to be able to be temporarily pinned in place so that adjacent bays can be poured concurrently. With a softwood joint there is no requirement for a sealant.

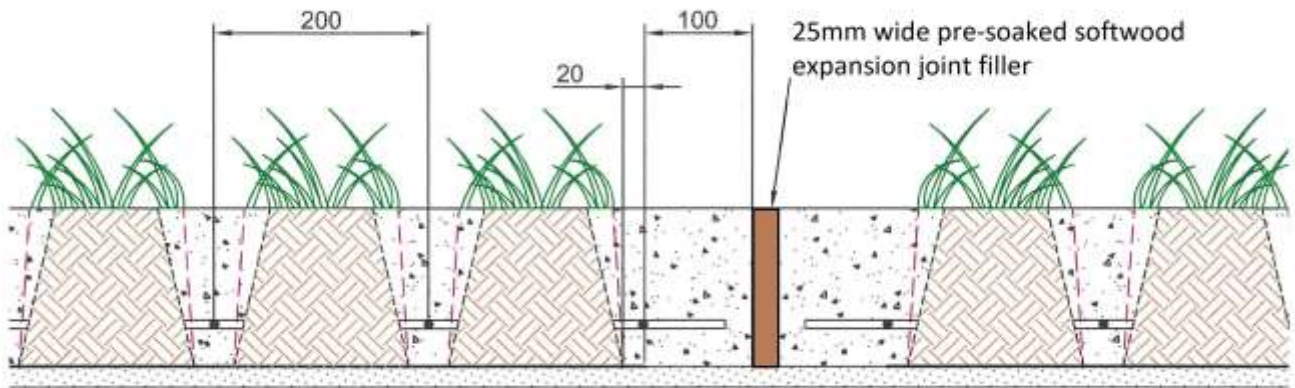


Fig. 9

In climate zones with a high temperature range (40° plus) additional compressibility will be required and this can be provided with a 20 or 25mm thick polyethylene (PE) foam filler, this will require sealing and to enable this the top 20mm of the joint should be underscored to enable removal and reinstatement with a cold pour sealant. For this we would recommend a single pack gun applied sealant such as Nitoseal MS300 or for potable water applications MS600.

A PE foam will not provide the same level of rigidity as a wooden joint and so where adjacent bays are to be cast concurrently there will be a need to use either 1) a temporary wooden filler, with slightly tapered side walls to enable removal, or 2) an aluminium channel 25 x 50mm deep sat over the top of the filler and removed prior to after initial set.

In certain circumstances dowelled joints are introduced for heavy load transference or in spillway waterflow situations, these should be installed as detailed in Fig. 10. and should only be used with the 150mm thick Grasscrete GC2 system.

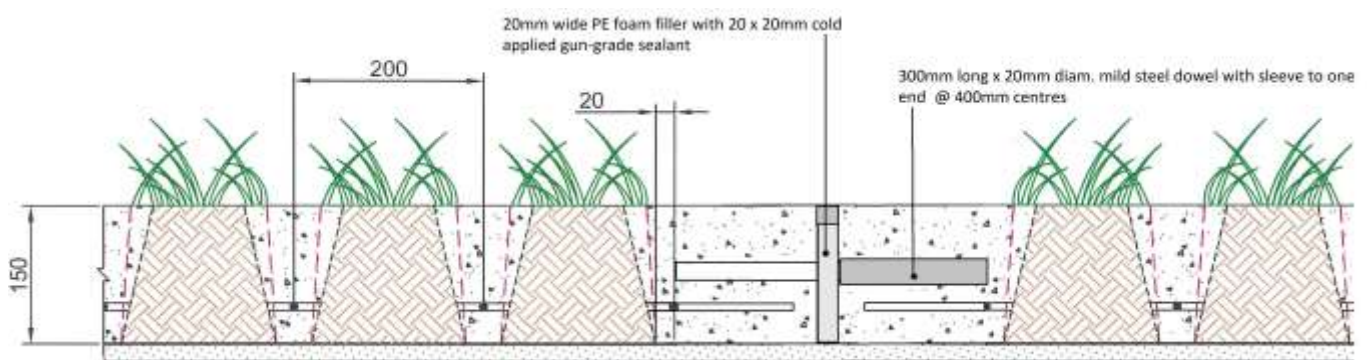


Fig. 10

Where dowels are used, care should be taken to ensure that they are set truly horizontally and parallel to each other, this can be achieved by the use of wire chair cages.

Concrete

Material composition and performance requirements.

For an installer, the ideal choice of concrete will be one that achieves the maximum flow with the minimum effort required for placement, enabling the concrete to move easily around the confines of the void former and the reinforcement. For the specifier and buyer the challenge will be to provide the required workability without compromising the integrity of the concrete.

For horizontal or shallow slope applications the key to achieving optimum workability, without structural compromise, can be found with the use of super-plasticised 'flowing concrete'. This will enable the required workability to be achieved whilst at the same time limiting the amount of free water within the mix.

For most applications the supply of flowing concrete will call for site addition of the superplasticiser, this is advisable for two significant reasons:

- 1) Once the superplasticiser has been added to the mix a window of workability of 45 minutes to 1 hour will generally be available, depending on the formulation of the admixture. To undertake the addition at the last possible moment will therefore maximise the period of the concrete's flowing state.
- 2) Flowing concrete is volatile in comparison to ordinary slumps and can result in truck spillage during transit, particularly if the route is undulating.
- 3) With site addition of the superplasticiser, the concrete can be assessed on arrival with a slump test able to compare the control mix against the specification.

Cement

For general purpose applications a CEM I type cement will be specified, with a minimum cement content of 350kg/m³, this should be incorporated with a maximum water cement ratio of 0.55. The w/c ratio can be reduced by the plant addition of a water-reducer, but this material should be cross-matched with the superplasticiser to ensure compatibility, particularly as some water reducers are themselves also plasticisers. In exposed locations the cement may be switched to a CEM II material using blended formulations of up to 35%. Use of Cem II cement can also be beneficial in hot climates, with a likely extended set period the risk of drying shrinkage can be reduced. It should be noted however that some CEM II mixes can leave a surface grout film that is susceptible to dusting under traffic use. As a consequence the aggregate will be revealed and this may or may not be desirable.

Aggregates

The size, shape, grading and ratio of the aggregates will significantly influence the structure and placement of the concrete. The castellated profile of the formers and the network of reinforcing wires means that the concrete has to be capable of being drawn through restrictions. This calls for the large aggregate to have a maximum size of 10mm, as a larger dimension could lead to honeycombing. Large aggregates will tend to be either quarried stones or gravels, with the latter being less angular than quarried stones such as limestone. Each type is suitable for use in Grasscrete, though a mix using limestone is likely to have a slightly more textured surface with particles standing proud of the surface.

The fine aggregate should be a suitably coarse sand and we wouldn't recommend the use of stone dust, the latter can have a clogging effect on the mix that suspends workability. The sand should be evenly graded and in this respect care should be taken if marine sands are used. The washing of such materials can remove fine particles, leaving a sand that doesn't easily grout lock onto aggregates, particularly smooth gravels, with segregation then becoming a possibility. To provide optimum workability and compaction the sand should constitute 45% by weight of the aggregate, enabling workable but cohesive mix to be achieved.

Admixtures

The type of concrete used for casting Grasscrete is capable of being improved by the introduction of certain admixtures, with particular benefit being found in respect of

- Workability and ease of placement
- Compaction and density

As part of the batching process a supplier may elect to use a water-reducing admixture, this can have the effect of lowering the water/cement ratio from 0.55 to as low as 0.43. The benefit will be a mix that can still provide the required control slump but that will have significantly less free water. This will help to reduce the incidence of water being drawn to the surface of a pour, potential for segregation, sand bleed and risk of drying shrinkage in hot weather. Some care should be taken in the selection of a water-reducer, particularly as some formulations are plasticisers and so compatibility with the superplasticiser should be checked. The concrete supplier should identify where such admixtures are proposed to be used and we recommend that they be asked for design mixes to provide a mix design certificate.

The specification of superplasticisers is now commonplace within the construction industry and so the use of flowing concrete is now less likely to alarm the client as it exits the chute of the truck mixer. In choosing a superplasticiser consideration should be given to the characteristics of the admixture. Technology has developed around a number of different base materials with earlier formulations tending to focus on either synthetic melamine derivatives or organic lignosulphonates, newer materials have also introduced naphthalene and polycarboxylate formulations that can provide a more tailored approach. In assessing the choice of material it would be advisable to consider the following factors:

- Sourcing and availability: If the superplasticiser is to be supplied by the ready-mixed concrete company you may be pushed towards using the material that they have in stock. The choice might be limited by supply chain agreements, that might centralise purchasing around one particular admixture manufacturer.
- Global manufacturers may also vary the formulation and even the branding within different territories, so check the availability.
- The territorial variation in available types may stem from the demands of the local climate, with for instance a formulation that offers a retarded set being beneficial in a tropical climate. Consideration should therefore be given to the characteristics of the admixture under the prevailing climate conditions.
- What period of enhanced workability is required? A melamine formulation will for instance typically provide a window of 30 to 45 minutes in a flowing state, but will then very quickly lose its workability. By contrast other formulations such as lignosulphonates may be less volatile and require a higher dosage rate but are able to maintain optimum workability for longer.
- Whilst in most cases an extended workability is beneficial there are examples of where it could be problematic. In cold climates there will be a need for the placed concrete to quickly revert to a normal setting mode to enable the Grasscrete to be edged trowelled and covered over.

The above points are best discussed with the concrete supply company so that the appropriate material is supplied. Another option, for regular installers, is to carry your own stock of admixture and agree with the concrete supplier to provide concrete to the control mix design. This might call for agreement, particularly of risk assessments in respect of the process of site addition.

The use of flowing concrete will be limited by the topology of a site. The profile of the Grasscrete void formers will naturally throat the flow of concrete enabling shallower slopes to still be cast with a fully flowing material. For steeper slopes however an adjustment will need to be made to limit the flow. This can be achieved by lowering either the initial control slump to the range of 50-75mm, or by lowering the dosage of the superplasticiser, or by using both options together. The type of aggregate and the angle of slope will call for some flexibility of thinking and our advice would be to lower the control slump as indicated and to then incrementally add the Superplasticiser until a level of workability is achieved that will hold on the slope. This in many cases will still see a slump of 100mm being available.

Prior to dosing the superplasticiser on site, care should be taken to ensure that the drum rotors are clean and this may require the blades to be washed using the truck mixer's hose pipe. Only a small volume of water should be used for this purpose. The additive should be decanted into a calibrated bucket according to the recommended or trial dosage rate and should then be introduced to the mix under low speed drum revolution. An experienced operator is likely to be able to visually gauge the optimum dosage during this process and might make slight adjustments to the quantity used. After the admixture has been dispensed the drum speed should be increased for a period of 5 minutes to ensure that the liquid has been evenly distributed.

Mix Design

Having considered the characteristics of the individual components, what will a typical concrete mix look like for Grasscrete? The actual batching figures will be dictated by the characteristics of the aggregates, particularly the strength of the cement, which can vary significantly around the World.

For Western European zones we would see as typical the following mixes for an application such as car parks or access roads:

Grasscrete: Typical concrete mix specification to EN 206-1: 2000		
		Normal XC3 exposure requirement
Reference	Specification	Comment
Mix Classification	C28/35	Cylinder / Cube
Cement type	PC	Cem I
Minimum cement	350kg/m ³	
Water/Cement ratio	max 0.55	Water reducers can be used
Max. aggregate size	10mm	
Sand as proportion of aggregate	45%	
Slump on arrival	S3	Target 100mm
Superplasticiser to be added on site in accordance with the manufacturer's recommendations	650-700mm Flow table test	For horizontal applications, dosage reduced for work to slopes. Optimum Workability window 45 minutes.
Air value	3%	Assumes 2% entrapped air in the mix plus 1% induced air from the superplasticiser, therefore no AEA addition.

Fig. 11

For works to slopes the mix properties will be broadly similar except as previously stated for a modification to the initial control slump (reduced to S2) and the subsequent dosage rate of the superplasticiser.

In some installations there may be an indication of early use, or a permanent risk of continuous abrasion to the pocket profile due to types of vehicle in use. For such projects consideration can be given to additionally incorporating fibre reinforcement strands into the mix. This shouldn't however replace the traditional steel mesh reinforcement, which will always be a vital component of the structural design. Please note that metal fibres shouldn't be used within the mix.

Coloured concrete can be effectively used with Grasscrete and further information can be found in our *Terratone* leaflet. The most popular colours are shades of earth brown applied as a dye at the batching plant. This ensures a through colour to the concrete. As an alternative a chem-stain can be applied to the surface after casting, this will provide a surface that is variegated and suggestive of patina. Chem-stains should be applied after the tops of the formers have been melted, to avoid stain build up around the void formers and to prevent the base concrete colour being exposed around the pocket

Concrete placement

Planning the process

A key factor in planning the installation will be the accessibility for delivery and placement of concrete and later topsoil. We recommend that ahead of commencement the following potential issues are identified.

- Does the route to site have any restrictions that might influence either the ability to get there or the time taken to do so, e.g. Low bridges, weight restricted structures, traffic diversions, designated routes.
- Are there any gate width restrictions that would prevent full size delivery vehicles from being able to gain access?
- Are there any trees along the route with a low over-hanging canopy?
- Are there any services that would impact on gaining access, e.g. shallow or un-protected drains or services, open manholes, or elevated manhole covers pending road make up?
- Is there evidence of any unsound ground conditions, adverse cambers, overly tight turns along the route?

Incidence of one or more factors might call for corrective action or the down grading of delivery vehicle size.

Assuming that the route to the work area poses no issues then the next consideration will be the layout of the area to be paved and the means of gaining direct access for placement. To consider this aspect we consider separately the requirements for trafficable installations and slope installations.

Traffic installations

In an ideal situation access would be available to drive down the side of a bay, to be able to discharge at will on a pre-set bay. In reality there will be circumstances where this just isn't possible such as:

- Fire access tracks with adjacent buildings or non-negotiable ground.
- The final aisle in a car park that has been land-locked by earlier pours.

Whether pouring to a fully pre-set bay or overcoming access difficulties, the actual process of placement will vary little, and in reality a pour with difficult access should take no more than 15 to 20 minutes longer to pour. How this time limit can be achieved is detailed on page 23, in the meantime we begin the guide to concrete pouring with a look at some basic techniques, before heading into the concrete pour however, some inspections are required:

1. Check the line, level and stability of edge formwork.
2. Establish that adjacent surfaces are protected from splashing.
3. Check for damaged void formers, pressing out any indents to pocket walls, or removing and replacing formers damaged beyond such a repair.
4. Check for incidence of void formers touching mesh reinforcement and re-align where required.
5. Check overall layout of formers for best alignment.
6. Check that there is a full depth available for the solid concrete edge. Brush any sand away from the formwork face that otherwise prevents this.

Once the direction of pour and the method of bringing concrete to the placement area has been established the process can begin.

The material thickness of the Grasscrete void former is intended to be sufficient to support the live load of concrete against the pocket walls whilst at the same time being sufficiently slender as to enable a quick and easy melting process at the later stage of removing the tops of the void formers. The thermo-forming manufacturing process will have varied the draw thickness of the material to optimise both requirements. Neither benefit will however extend to enabling the formers to be directly foot trafficked by the installer. There is a requirement therefore to either use duckboards for the operatives to stand on, or alternatively a staging board platform can be erected that spans over the formers. The duckboards can be plywood or similar sheets of a manageable size. Both options will also be used to accept the initial concrete discharge to prevent disturbance and damage to the void formers. An example of using duckboards is featured in *Fig. 12*



Fig. 12

When discharging concrete, the temptation might be to think of waiting time costs and delivery driver prompting that can lead to a decision to discharge the concrete in a heap. That might be fine for other forms of concreting but for Grasscrete it should be absolutely avoided. Let the concrete company know the length of time on site, do a deal over the costs and inform the delivery driver who is in charge of the process. That enables the installer to methodically pour and finish the concrete in one continuous process, reducing in doing so the risk of damage to the void formers and the risk of laitance and excessive texturing at the surface.

The key tool in the casting process is the squeegee, this should feature a 900mm wide aluminium blade complete with a rubber insert and, with the blade mounted on a long broom handle. An experienced operator will deftly manoeuvre the tool during pouring. A less experience installer might want to saw cut the blade to a 700mm width.

The squeegee has a multi-purpose roll of being able to both push and pull concrete and then to flat blade across the tops of the formers as shown in *Fig. 13*.



Fig. 13

The squeegee is used in a number of different positions for a number of different purposes. Position 1 as shown in *Fig. 13* is used to finish concrete to the tops of the void formers, it is also used for placing the sand blinding layer and for levelling topsoil. When concreting the concrete is drawn back towards the installer to finish it flush to the top of the void former. It is pushed away from the installer to relocate concrete elsewhere. The squeegee can also be held in this position at the base of discharging concrete so as to direct the flow away from the duckboard. The levelling process is often undertaken in tandem with two installers, alternating their draw, this helps to ensure that the concrete is kept tight to the tops of the formers reducing the incidence of laitance or blade marks in the surface. When using the squeegee in position 1 the blade should be drawn diagonally across the top of the formers, this ensures that it will always run in contact with the tops of the formers and won't drop down between them, which would cause an uneven surface.



Fig. 14

In *Fig. 14* we show position 2 for the squeegee which is used to pull thicker layers of material into position. When concreting this is more likely to be used in situations where access restricts the ability to use position 1. In this case an adjacent concrete wall means that the concrete is being worked from three sides instead of four.



Fig. 15

The final squeegee position is position 3, as shown in *Fig. 15*; this sees the face of the blade laid flat to concrete allowing the blade to be either pushed or pulled across the surface, with the shaft at a steep angle. This technique is used to finely level the surface where imperfections may have been left, particularly with mixes that have been less workable than the norm. This method is also used to fine level sand blind material.

With the concrete satisfactorily drawn to the tops of the void formers the concrete will shortly begin to revert to a normal slump and will begin the set process. Once the surface offers resistance to touch, the edges can be trowelled as shown in *Fig. 16*. This should be undertaken using a 'arris' edging trowel to leave an edge that won't be damaged during stripping of formwork. With the concrete now in place it's important to wash down all tools and equipment, super plasticised concrete, particular with synthetic formulations for admixtures can be difficult to remove when set.



Fig. 16

Working with no side access

Page 19 of this guide identifies circumstances where side access might not be available to cast concrete. In such circumstances initial thoughts might be towards pumping the concrete, but we would always suggest that this method should be used as a last resort. Pumping will not increase the potential daily volume and can be both logistically and financially challenging.

In trafficked situations, it should be reasonable to assume that access can be gained up to the work area, if not perhaps to the side of the particular bay to pour. This is a common feature with fire access routes to the perimeter of buildings and to the last remaining aisle to pour in a car park, which will be surrounded by recently cast areas and will therefore be land-locked.

If the width of Grasscrete to pour is sufficient to enable a truck mixer to drive along the sub-base then *Fig. 17* shows the best methodology.



Fig. 17

In this scenario Grasscrete formers and mesh reinforcement are placed in position to an overall length that enables 1, 2 or 3 sheets of mesh reinforcement to be placed in position and lapped. The exact number will be dependent on a number of factors:

- The ability for operatives to move and work around the perimeter of the bay, if only able to work from one end, this would suggest that only one sheet of mesh and the corresponding area of formers should be pre-set.
- The workability of the concrete.
- The number of chutes carried by the truck mixer will dictate how far into the bay the concrete can be discharged.
- The depth of Grasscrete to be installed and the width to be laid. For example 150mm Grasscrete GC2 laid within a 6 metre bay requires less repositioning than 76mm thick GC3 within a 4 metre wide bay.
- The reach of the installers; a 5' 2" installer wielding a short shafted squeegee is going to struggle to pull concrete across a significant distance.

Once the selection of initial length is made, the panel should be set in position in a normal manner. It is important to stress that care should be taken at this point, to ensure that the initial alignment of the formers can be maintained throughout each subsequent set up, to avoid unsightly stepping in the eventual lines of grassed pockets. It is certainly worth at this

Stage, drawing a string line along the full extent of the aisle to identify that all will fit. During the process of casting it is also good practise to routinely step back and look down the line of formers to ensure that they are consistent, particularly at lap points for the mesh reinforcement.

Once the initial layout is in place pouring can commence, this may require slightly more elevation to the chute to achieve the required length of throw, but apart from this and the demands of extended reach the pouring is a normal process. Once the head of concrete reaches a point 500mm from the edge of the last mesh sheet, it's time to move the truck mixer forward. Work should then begin on screeding out any depressions caused by the truck mixer's wheels. After this a second panel is set up, in the manner of the first and the truck mixer is returned into position and the process repeated.

With practise, casting in this method should take no more than 15 to 20 minutes more than a side pour.

Working to restricted widths

In circumstances where access can't be achieved, either for a full sized truck mixer or for a mini mixer then consideration needs to be given to a double handling process. Again at this point thoughts might turn to pumping, but those concerns expressed earlier about the viability of pumping have only been heightened by the restricted width. Concrete can be poured via a range of mechanical plant that offers a controllable rate of discharge. Where site dumpers are used we recommend that a plywood sheet is placed at angles onto the front wheels to provide a chute, that then reaches down onto a duckboard of the same width, with a stop lath nailed to it to retain the board in position. Care should be taken to ensure that the speed of placement is consistent with the concrete available, if there is a long run from the truck mixer to the Grasscrete then it would be prudent to reduce the size of the delivery so as not to impact on the workability of the concrete over the extended timescale of pouring.

Casting to slopes

Installations to slopes will often see Grasscrete integrated into a contiguous programme of activities that require careful planning and co-ordination. Such projects might be restrictive in respect of access and working patterns and so we recommend that a programme is drafted ahead of the works in consultation with those involved in the contiguous activities.

The works will often be linear and the first question will be how to orientate the bays, particularly for long slopes. The answer to this question is often determined by the plan profile of the works. For example, if a rectangular spillway is of significant dimensions in both length and width and is evenly graded in profile then it might not matter which round the casting takes place. The exception might be where the design calls for dowel bars to be installed to joints that run perpendicular to the flow passing down the spillway. In such circumstances it's likely to be easier to install via horizontal long strip bays.

In most other cases the determining factor will be the plan shape of the works, the more the profile varies the greater will be the need to segmentally re-align the bays. Such alignment will require the void formers to be stepped at the edges within a picture frame of solid concrete that creates a distinct vee-shape at the joints. The greater the chord width of the bay relative to the arch of a slope then the greater will be the degree of stepping and extent of the vee-shape at the vertical joint. A compromise can be found by reducing the chord width that in turn minimises the segmental re-alignment with each bay. To be able to maintain a satisfactory rate of progress with narrower width bays the answer is normally to cast in long strips laid out from top to toe.

With most slopes, there will be a need to double-handle concrete as there is unlikely to be direct access for casting. The temptation might be to consider pumped concrete but as with horizontal work such a decision should be carefully considered. The likelihood is that pumping would be a costly process, would not aid productivity and could lead to control issues that might even be hazardous. A conveyor placer can be an option, where available, but this will generally require access to the base of the slope, as well as which it might not be able to fully reach all of the bay. In the majority of cases the preferred method of double-handling will be to cast by using a tracked 360° excavator. The speed and effectiveness of this can be dictated by a number of factors:

- How close to the works the process of truck mixer discharge into excavator bucket can be.
- Whether the slope can be traversed by the excavator the ability to do so could reduce the required size and reach of the machine.



Fig.18

With larger scale projects a top to toe bay alignment can offer flexibility not found with pre-cast concrete block systems, which must be laid in a continuous linear sequence to enable modular fit. With Grasscrete and as *Fig. 18* shows the bays can be discontinuous allowing several separate areas to be progressed, with the certainty that they will be eventually, seamlessly connected. Depending upon the gradient of the slope consideration can be given to establishing a work platform as shown in the same photograph. There are variations of a theme for such a platform examples of which include ladders constructed from re-bar with trestle supports for a horizontal staging board that spans the width of the bay. In this same photograph it can be seen that pouring involves the use of a 360° tracked excavator using a concrete skip and working from the base of the slope.

Start at the top or the bottom? This can be very much down to the preference of the installers, the normal adopted method is to start furthest away from the excavator with the boom at its most extended. The concrete would be positioned so that it can then be worked using the fall of the slope.

The gradient of the slope will dictate the level of slump selected for the pour but this will still be much higher than would be the case with a pouring of solid concrete. The castellations of the Grasscrete void formers help to throat the flow of concrete and with the structure being only 50% concrete the live load and potential to surcharge is much reduced. In most cases this can see a slump of 75mm being suitable for pouring.

Of course a slump of 75mm is much less than flowing and this will impact on the ease of moving and finishing the concrete. The surface finish as a consequence, will be more textured, but for a slope this is desirable to enable a slip resistant surface to be achieved.

A specification may call for the installation of ground beams, to the toe of the slope for anchorage and avoidance of sub-grade loss, or to the junction with the crest to prevent surface water intrusion into the slope. If the beams are shallow thickenings to the edge of the slab, they can be constructed monolithically with the rest of the Grasscrete. If however they are deeper beams to cast monolithically is likely to cause an uplift due to a pressure head from concrete above. Deeper beams will therefore require either a two stage filling process with a partial set of the first stage before completion, or alternatively the beam should be cast as a separate structure. The decision on this will be a design matter and therefore the process should be established ahead of the works.

How much concrete?

The Grasscrete brochure will indicate the average coverage for concrete, but this figure will vary according to the width of the area and the corresponding ratio of voids to solid concrete. *Fig. 19* therefore takes this guide a step further with a breakdown of coverage for 1m³ of concrete according to typical widths.

Grasscrete: Concrete coverage calculator			
	Linear metres of pour per cubic metre of concrete		
Grasscrete width	GC3	GC1	GC2
1.0	19.2	16.3	10.1
2.0	10.2	7.8	5.5
3.0	6.9	5.0	3.7
3.5*	5.9	4.3	3.2
3.6	5.8	4.3	3.0
4.0	5.3	3.8	2.8
4.5*	4.6	3.4	2.5
4.8	4.4	3.2	2.4
5.0	4.2	3.1	2.3
6.0	3.5	2.6	1.9
7.0	3.0	2.2	1.6
8.0	2.7	1.9	1.4

Notes * allows for a 150mm wide outer edge
 Figures shown are approximate, some variation will occur due to: Curves, inclusion of manholes etc and varying centres of expansion joints.

Fig. 19

Concrete curing and protection

A traditional concept of curing will call for the retention of moisture within the structure for continued hydration over a period after casting. This can be important to counter high air temperatures or the heat of hydration from cement, particularly in mixes with a high cement content.

With traditional concrete slabs laid onto sub-bases, the method of curing will tend to be limited to the upper surface, with the application of either a liquid or sheet membrane. A drawback with this methodology is that it tends to cure only the upper surface, with no means of retaining moisture in the lower section. This can see moisture being lost into the underlying base.

Grasscrete is cast onto polystyrene formers and these will prevent moisture loss both at the base and through the walls of the individual pockets, leaving just 50-55% of the surface exposed. Where there is a risk of accelerated moisture loss through the surface then this should also be covered for the initial 48 hour period, prior to melting the formers. Where spray-on curing membranes are used they should not be solvent based due to a risk of reaction with the subsequent hot works operation.

The surface should be covered where there is a likelihood of inclement weather. Where rainfall is likely the covers should be polythene of sufficient thickness not to distort under water loading and be the cause of surface puddling. Care should also be taken to avoid dragging the polythene sheets across the surface as this will leave marks in the surface finish. If the levels of rain are low in intensity and the concrete has achieved initial set then it might be decided not to cover the surface. Water that might accumulate at lower levels can be relieved by piercing a number of void former tops. Where there is a risk of frost the surface should be covered with a 10mm thick polyethylene foam (PE) blanket rolled out across the surface. Particular attention should be paid to the edges if steel road forms have been used, to prevent the formation of a ‘cold bridge’. PE foams offer an ‘all year’ function as the insulation qualities are also effective in protection the surface during hot weather.

For tropical climates we recommend that the Grasscrete is covered over with hessian that is kept wetted throughout the day, this should be followed at the close of the day by a polythene membrane. This will encourage evaporation to be held captive on the underside of the polythene.

First use

Assuming ambient temperatures prevail, then Grasscrete should offer the load bearing capabilities detailed in Fig. 20 throughout the curing period. We should stress that this information is a guide as low temperatures may slow the curing process.

Grasscrete: Load capability in curing period			
	Curing period (under normal conditions)		
Type	7 days	14 days	28 days
	Gross vehicle load (tonnes)		
GC3 / A142 mesh	1.0	2.0	3.4
GC3 / A193 mesh	1.3	2.5	4.3
GC1 / A193 mesh	2.0	6.0	10.8
GC1 / A252 mesh	2.7	8.0	13.3
GC2 / A252 mesh	6.0	20.0	30.0
GC2 / A393 mesh	8.0	26.0	40.0

Fig.20

Removing tops of void formers

The Grasscrete void former has been manufactured, so as to easily enable the hot works removal of the upper layer that is visible following completion of concreting. Prior to the process, a number of measures can be taken that ease the melting of the former tops:

- Ensure that during concreting the concrete is finished tight to the tops of the formers and that there is no residue left over the tops of the void former.
- Pierce the top of each former with a steel pin before applying the flame. This will provide an edge for the flame to focus on, reducing the labour time and heat concentration required for each pocket. Please note that the purpose here is to simply penetrate the top of the former. Using heavy bars or poles to push the former down will be counter productive as it will create inconsistency in the subsequent level of melting. It also takes the heat concentration down into the base of the pocket that can lead to the chair spacer or any underlying geotextile being place at risk.
- The key to maximising efficiency is to seek the highest possible calorific value over the shortest concentration of time, from the equipment used. Where using LPG flame guns a triple headed tool will enable three pockets to be melted simultaneously. If LPG is selected then we recommend the use of propane gas, if this isn't available then a blend of propane and butane can be considered. With a high calorific gas the styrene will quickly melt the top of the former with a minimal draw down the side wall.



Fig. 21

Fig. 21 shows a typical melting process using 47kg propane gas cylinder. As the photograph indicates there is no burning of the formers, which should as previously stated be avoided. Should a former set alight the extent of the burn will be limited to that single pocket and a handful of sand thrown into the pocket will extinguish the flame, this will avoid a soot deposit being left around the rim of the pocket. As the photograph shows a fire extinguisher should be available for any emergency situations, For many projects a *Hot Works Permit* will be called for and this will outline the site specific requirements of both the operation and the storage of tools and equipment.

Melting of the void formers does not cause hazardous emissions, with the process being in many ways similar to the charring of wood. As a consequence a low level of CO₂ will be emitted that should be compared to the long term benefits of CO₂ digestion that the completed Grasscrete will enable

Topsoiling

The topsoiling operation will involve use of the material with the most potential for variability in composition and physical characteristics. We can however offer a number of guidelines for material selection and installation.

The topsoil should as a first requirement be capable of enabling germination and continued growth of grass. This will call for a pH value of 6.5 to 7.0, with 7.0 being pH neutral. This slightly acidic nature is generally recognised as being ideal for lawns. It will also help to maintain a balance should there be carbonisation from the concrete, which would elevate the pH level should it wash into the topsoil.

It would naturally follow that a local soil is more likely to support indigenous growth and so the search for a suitable topsoil should ideally begin close to the job-site, indeed the search can begin on the site. If the works have involved the site strip of virgin topsoil and there is space to have stored this, then that would suggest the ideal material. For it to be suitable for placing into the soil pockets it would call for the removal of previous vegetation during the site strip and for it to have been covered over to keep it dry.

If topsoil is required to be imported to site then generally it will need to be either a screened or rotovated material from a reliable source. Some care should be taken in the selection to avoid 'topsoils' that consist of the dust residue from aggregate re-cycling, blended with dried sewage, as the only certainty of growth will be *body* will tend to suffer from liquification during the permeation process leading to a frequent need to top up the finished levels as well as a cementation of the fine particles. Small stones are acceptable as they can help to prevent cementation. Some projects may call for a known standard of topsoil to be used and this may override some of the comments of earlier paragraphs. It is important to raise awareness with the specifier of any issues that might arise with using a prescribed standard.

Once the tops of the formers have been melted the topsoiling can begin. For large projects this can involve mechanisation with the use of excavators or loading shovels to place and level the soil. Care should be taken however that excavator buckets aren't dragged across the surface as this will cause abrasive damage to the surface, particularly to the pocket surrounds. Where multi-purpose backhoe buckets are used we recommend that a timber batten held within the jaws of the bucket clamshell is used to grade the surface layer. At no time should steel tracked excavators ever drive over Grasscrete as they will damage the surface.

For many projects there will be a need to either fully place the soil, or to finish it by hand. With a suitably dry material these operations can be undertaken with the use of either the standard squeegee or a stiff brush or both.



Fig. 22

Fig. 22 shows that a slight surface residue of soil should be expected particularly with a concrete surface that is textured. If the surface isn't to be trafficked in the immediate future then it is a worthwhile exercise to leave a layer that is a little thicker (0-5mm). This will help to naturally replenish the soil levels over the initial few weeks as it is gradually washed into the pockets; - in so doing topping up any settlement that will have taken place within the pockets themselves. It can also benefit germination by toning down the whiteness of new concrete that can otherwise reflect sunlight causing a localised temperature elevation.

Before over-soiling the programming of use should be carefully considered. If early use is called for then the soil will need to be drawn as flush to the surface as possible. In all probability some topping up of the levels will be required and this may call for a rotation of vehicle movement to provide easier and safer access to the works.

If the Grasscrete area is to be used for site based haul and storage activity after installation, then it would be best to defer the topsoiling until after site traffic movement has ceased, this will avoid detritus being grafted into the topsoil. If plant movements are to include tracked machines then excavator mats should be placed over the Grasscrete.

Grass seeding

The advancing technologies in seed development coupled to our shifting climate means that the divisions between *in season* and *out of season* are no longer as clearly defined as they used to be. In many cases now, for a Western European climate, it is possible to sow seed for most if not all of the year. Seed development in many cases enables seed to lie dormant in the ground until the conditions are conducive to germination.

The grass seed should be sown as close as possible to the surface and if the topsoil levels are likely to settle significantly then it is best that this settlement is allowed to take place before seeding. If the Grasscrete is over-soiled then the seed can be broadcast within a 0-5mm layer of soil and the natural soil filtration back into the pocket will sustain the germination process. During the period of germination the manual movement of topsoil layers should be avoided as this can disturb germination.

We recommend that during dry weather a programme of watering is developed for the germination process and earlier stages of growth.

In desert climates grass growth is likely to be more successfully developed from turf. By using a *cookie cutter* individual turf shapes, to match the plan shape of the pocket, can be heeled into upper 25mm of the soil pockets. These should be intensively watered for the initial week, followed afterwards by a programme of irrigation. Further details are available on request about the incorporation of pop-up sprinkler irrigation systems into Grasscrete bays.

The Grasscrete brochure details the seed mixes appropriate to circumstances of use, these are for the Western European climate range. For other climates, discussion should take place with seed merchants and growers to cross match the appropriate species and cultivars. We are happy to assist you in this process.

Gravel fill

In circumstance where the primary purpose of specification might be the establishment of a permeable slab, the decision might be taken to fill the Grasscrete pockets with granular material instead of topsoil and grass seed. The ideal material for such circumstances will be a 20-5mm graded gravel. This will be easy to work into the pockets with a squeegee or brush and once in place will lock into position and prove difficult to displace by either washout or wheel movement. Such a grading will optimise permeability and be more resistant dirt and growth colonisation than would be the case with a smaller size aggregate. Decorative effect can be gained by using granular material of contrasting colour to the concrete, or alternatively in using coloured concrete.

When filling the pockets with gravel care should be taken to ensure that surface stones are swept from the surface to prevent Foreign Object Damage (FOD) caused by tyre flick.

Concrete remedials

Within this section we take a look at the control of defects in construction and the retrospective repair process for structural damage.

The manufacturing process for the Grasscrete void former calls for a component that is sufficiently rigid to be able to accept the live load of concrete, yet at the same time thin enough to be capable of being easily melted. The wall thickness of the former is calibrated to optimise thickness at key points of stress during concrete casting. Some variation in the finished characteristics of the former might be experienced due to the nature of the re-cycled raw material and how it reacts to a thermo-forming process. This variation might, when combined with a concrete surge, see the upper plan shape of the former become distorted. In the vast majority of cases this will see only a slight squeezing of the pocket shape and as such this will not require remedial attention. In some isolated cases the effect on the pocket shaped might be more marked and will require remedial attention.

It is also not unknown for a foot to inadvertently step into concrete during the pour with a resulting destruction of a void former pocket. In such circumstances it is best to focus on maintaining the surface level at that point rather than following the contours of the damaged former which will now be lower. Beneath the distorted shape of such formers, there is likely to be a void that is adequate for its function. Attention can therefore focus on recovering a plan shape at the surface that is acceptable. This can be achieved by the use of a 38 to 50mm core bit, depending on Grasscrete type, drilled through the outer points of where the cruciform arms should be. If further defining work is needed a 100mm diameter angle grinder can be used to re-form the straight edges of the shape. This should recover a pocket shape of acceptable proportions and without structural compromise.

The need for some remedials might stem from actions that are absolutely nothing to do with the installer. Occasionally we are asked to advise on remedials to areas that have suffered from a number of issues such as: excavation for new service trenches, damaged caused by overload or inappropriate use, or the need to simply re-shape an area. This type of remedial work will call for sections of Grasscrete to be removed and replaced. Where the area involved is a significant part of a bay then the process is:

- 1) Saw cut the full bay into panels approximately 1200 x 1200mm in size.
- 2) Lever the up one edge of a panel, using an excavator if needed .
- 3) Punch downwards into two adjoining pockets so that the soil fill falls out.
- 4) Fish a lifting chain through one pocket and return back up through the other, lock the shackle in place and lower the panel down.
- 5) Repeat this process to the opposite side of the panel.
- 6) With the lifting chains in position the panel can now be lifted and removed from the area.

Some remedials might call for only the partial replacement of a bay and for this there is a process the enables damaged sections to be removed and replaced, whilst at the same time achieving continuity with the remaining concrete. This process is detailed in *Fig. 23*.

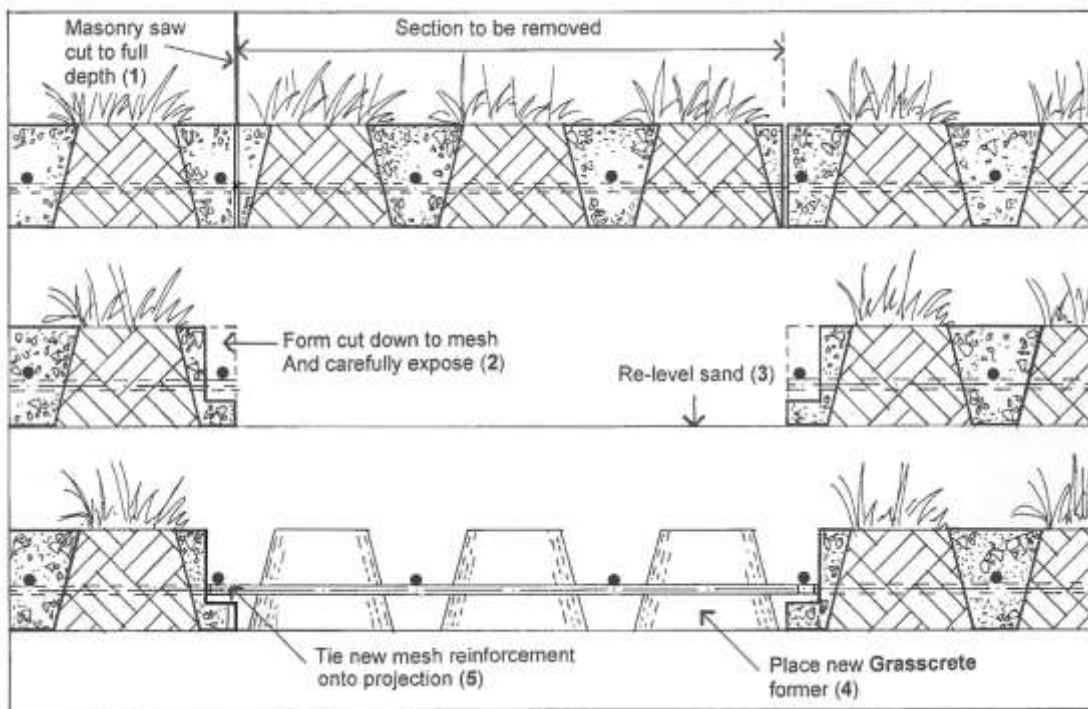


Fig. 23

Care and Maintenance

Most installers will not be involved in the maintenance of the Grasscrete apart from perhaps the establishment of grass growth and its care throughout the defects liability period. There is however, likely to be a need to pass on care and maintenance information to the client, often through the medium of an Operation and Maintenance Manual (O & M). We therefore detail below our recommendations for both **traffic** and **slope** installations:

Traffic

In a regular use scenario the passage of wheels along the Grasscrete surface will tend to trim the grass to the extent that cutting is rarely required. This can lead to some variable growth with areas not subjected to traffic featuring the prostrate growth of creeping grasses, whereas the growth in trafficked areas is likely to be predominantly of hardy perennial species able to quickly recover under use. Accessibility for grass cutting equipment will be geared to the presence or otherwise of road kerbs. Should kerbs not be required we recommend that the adjacent landscape areas, if grassed, be finished with a slight fall down onto the Grasscrete. This will enable mowers to traverse to and fro without the need to raise the mower blades. Where kerbs are installed this will generally call for the perimeter grass within the Grasscrete area to be cut by strimmer.

For applications such as fire access lanes it will be important to maintain visibility of the solid concrete edge margin for driver's identification, prostrate grass growth over the edge margin should therefore be strimmed.

The main focus of attention will be the regularly trafficked areas such as in the access aisles of car parks as well as those areas that have full time parking during daylight hours. The cruciform plan shape of the Grasscrete pocket is designed to resist wheel intrusion and so growth at the root bed will develop and continue under use. To help maintain optimum grass levels in a trafficked area we would recommend a bi-annual Spring and Autumn maintenance regime, which would feature the following:

- Grub out any pockets that have been subjected to oil spills, this is likely to have caused die-back but only on a local scale as the concrete surround to each pocket will have prevented further migration. Re-fill the pockets with topsoil and grass seed.
- Loosen any compressed soil that has led to die-back, this may be more evident in entrance and exit areas. Top up soil levels and re-seed as required.
- Top up low soil levels with a screened top soil material, maintaining soil levels at not greater than 12mm below the surface should ensure that the concrete edge to each pocket is protected from impact.
- Apply a liquid based nitrogen rich fertiliser in Spring and a liquid based phosphate fertiliser in Autumn, to respectively promote Spring /Summer growth and Autumn/Winter consolidation. The use of granule preparations should be avoided as there will be a residue retained on the concrete surrounds , which will then be washed into the pockets causing an overdose.
- To guard against inappropriate loading and use for Grasscrete GC3 and GC1 installations we recommend that, width and height limiters be considered in the design, where the potential exists for unplanned overload.
- Should damage occur to isolated areas of installation, particularly the methodology identified in *Fig. 36* can be used to effect a structural repair.

During periods of initial topsoiling and subsequent topping up, a need for some care should be advised to users of the installation. We would for instance recommend that a notice identifying *Caution temporary surface, walk with care* be erected in an appropriate position. Once the grass has firmed up within the pockets then the surface will be much easier to walk on.

Slopes

The expectations of maintenance requirements for slopes will generally be somewhat different to those of traffic applications. 'Less is more' might be the typical approach, although there are some elements that should be considered.

For slope applications the Grasscrete will normally have been installed as an armour layer and often to defend against water flow. We therefore recommend a periodical inspection of the surface to identify any instances where soil has been eroded from individual pockets. If left without treatment the empty pocket could cause turbulent flow and a progression of the problem to adjacent pockets.

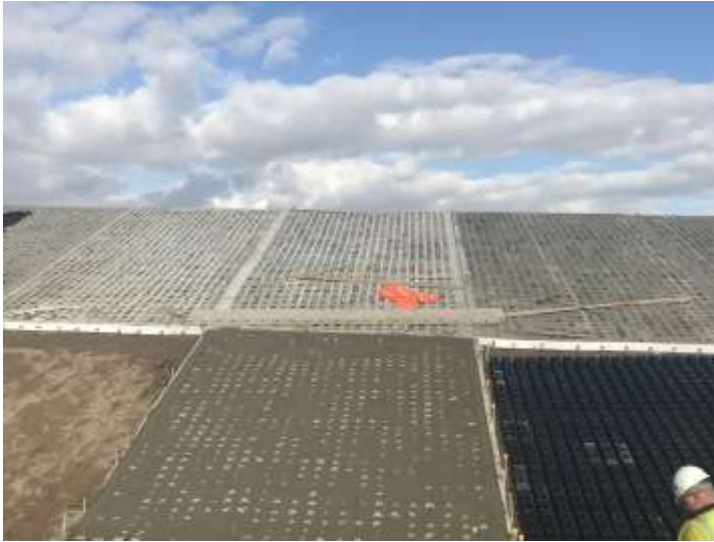
More often than not the maintenance issue is of “over-maintenance” this can be a consequence of the height of grass mowing or intensive grazing by cattle or sheep. It is important for water flow applications to maintain a grass height that is long enough to flatten under impounding and under such circumstances a grass height of not less than 150mm could be expected. This can be reduced for applications that are not likely to be subjected to water flow.

The principle element of maintenance is likely to focus on colonisation as rivers, reservoirs and lakes are normally to be found in areas of diverse fauna and flora. There could be potential for shrubs and grasses less appropriate to hydraulic efficiency to intrude into the landscape. Such growth should be attended to at an early stage to prevent long term establishment and the subsequent down-grading of performance.

Grass cutting to slopes can be undertaken with tractor mounted gang mowers where access and angle of slope permits. In less accessible areas grass cutting may involve a simple hover mower or pull chord as shown in *Fig.37*. In waterside applications this process should always be undertaken with the operative positioned on the crest side of the mower.

Where the Grasscrete installation is linked to water flow, either by direct contact or by secondary run-off, the use of chemical fertilisers and weed killers should be prevented and machinery should be used under a strict anti-pollution protocol.

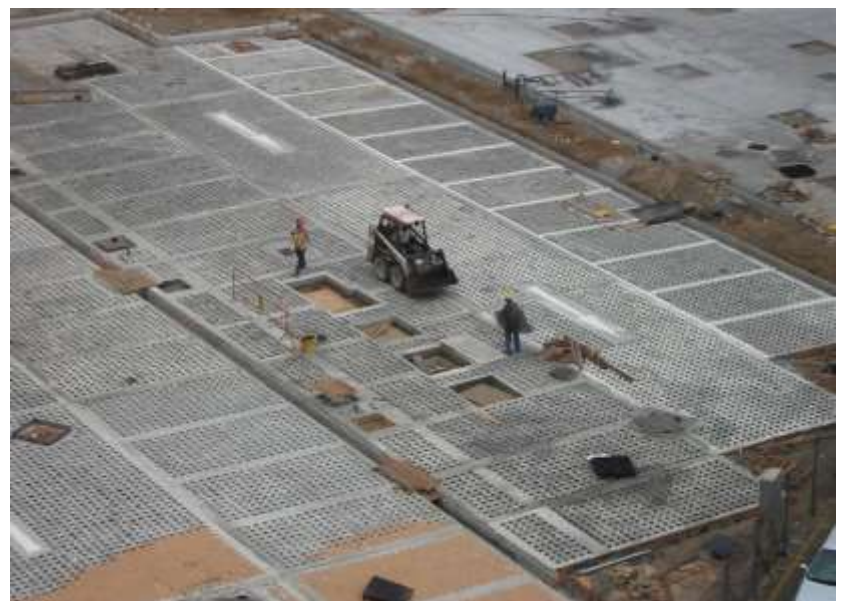
Gallery



Stages of construction



Stages of construction





Summary

The intention of this guide has been to provide the installer with a working knowledge of construction principles and techniques. With over 45 years' of experience we have a significant wealth of anecdotal evidence to respond to design and construction enquiries and we are at all times happy to discuss with you the contents of this guide or indeed any elements that we haven't covered, but most likely have experienced.

Some of our photographs are from our back catalogue of projects and are designed to highlight the actual process, which will be still current rather than requirements for Personal Protective Equipment, which maybe not

Due to having a policy of continuous product development, information that we have provided in this publication is subject to change without prior notice.

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