



# Association of Professional landscapers

## Driveway Installation Guide

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## **Introduction**

This guide is intended for the use of APL members and others to assist in delivering a high-quality installation and to help provide clear and consistent specifications to clients.

These guides have been adopted as training aids for APL apprenticeship and WSUK. They have also been adopted by external organisations such as

The Landscape Academy. [www.landscapeacademy.co.uk](http://www.landscapeacademy.co.uk)

TASK. [www.taskacademy.co.uk/](http://www.taskacademy.co.uk/)

Kebur Training [www.kebur.co.uk/landscape-training/](http://www.kebur.co.uk/landscape-training/)

### **For the purpose of this guide**

The following guidelines are set as a minimum standard and are intended to work in conjunction with British Standards specifications

specialist advice should be sought if building on poorly drained, heavy clay, very sandy soils or soils that may contain a high organic material content.

All works should be carried out following the relevant health and safety regulations.

If in any doubt you should consult B.S. 7533-101, or a structural or civil engineer.

The guide has been formatted in order to follow a logical progression and is divided into the categories of:

Materials, design, process and construction.

During the creation of these guidelines, many references have been made to specifications that have been created by skilled and dedicated professionals. To these inspirational people we would like to express our gratitude and respect.

## **1. Materials**

### **2. Types of unbound sub-base material**

#### **TYPE 1 SHW CLAUSE 803 (FORMERLY MOT) (DTP1)**

- Type 1 is a granular, well-graded material sized from 63mm to dust, but with most of the material sized at 31.5mm to dust. Type 1 SHW Clause 803 (formerly MOT Type 1) is widely used as a sub-base and base in the construction of roads, car parks and pathways. The mixture of stone and fines compacts to ensure minimal voids and provides a strong and durable sub-base.

#### **TYPE 3 OPEN GRADED SHW CLAUSE 805**

- Type 3 Open Graded SHW Clause 805 is a pure crushed stone, ranging in size from 40mm down to dust, but with a reduced (not zero) fines content. Type 3 is widely used as a sub-base and base material for projects where a lower fine content is required for improved drainage. (SUDS compliance)

#### **40MM–75MM CLEAN STONE**

- This is a crushed stone with no fines that ranges in size from 40mm–75mm. When compacted, it provides a hard-wearing and well-drained sub-base and base for use in roads, paths, drainage ditches, sport pitches, etc.

#### **SCALPINGS**

- Scrapings are typically used as a medium quality backfill to structures or as a sub-base and base material for access paths, car parks and driveways. They can be used as an alternative to Type 1 SHW Clause 803 (formerly MOT Type 1) for light-use applications or where a lower load bearing capacity is acceptable.

#### **TYPE 1 CRUSHED CONCRETE (dtp1)**

- 50mm down to dust. Best used as a sub-base and base for roads, underneath blocks, as well as layering in between concrete or tarmac and as a hard core for projects such as car parks

#### **TYPE 2 CRUSHED CONCRETE**

- 75mm with reduced fines. Crushed Concrete Type 2 is a standard sub-base material for roads but can be used for a wide range of other applications including drives, tracks, paths and foundations.

### **TYPE 3 CRUSHED CONCRETE**

- 0-63mm reduced fines

### **Oversized Clean Crushed Concrete**

- 75mm-100mm (no fines)

### **Hardcore**

- The term 'hardcore' refers to a mass of solid materials used to raise levels, fill irregularities in excavations and create a firm and level working base onto which heavy load-bearing surfaces such as stone or concrete can be laid. The hardcore then helps evenly spread loads.
- Hardcore may be used in the formation of paving, driveways, foundations and so on. It may also be used on its own to form a temporary road surface on construction sites
- A variety of graded materials can be used to make up a hardcore layer such as:
  - Construction waste such as brick and broken tiles.
  - Crushed rock
  - Clean, graded concrete rubble.
- The chosen materials need to be sufficiently hard as well as being capable of being sufficiently compacted before the upper layer is added.
- The material should also be resistant to deterioration, chemically inert, should not be absorbent and frost resistant.

*Other types of sub-base material are available, and their suitability should be verified before commencing works.*

### **3. Bound base material**

#### **CBGM (Cement Bound Granular Mixture)**

- HBMs (hydraulically bound mixtures) are a mixture of aggregate with a binder (cement) that sets through hydraulic action. The traditional HBM in the UK is CBM (cement bound macadam). This is now more commonly known as CBGM (Cement Bound Granular Mixture).
- CBGM (cement bound granular material) is a cost-effective way to build a heavy duty, durable pavement and offers an alternative to more traditional flexible material.
- HBMs can be used in road foundations (as a stronger alternative to traditional unbound Type 1 sub-base) or in flexible composite pavements where it replaces the asphalt base layer. (This type of construction is not commonly used in domestic landscaping)

- HBMs should not be mixed in concrete mixers on site. Careful mixing is required because of the low cement content, and there is a need to ensure that it is evenly spread throughout.

#### 4. Concrete

- When using concrete as a base there are some basic considerations to take into account such as:
  - The required strength of the concrete
  - Any requirement to reinforce the concrete,
  - Mix ratios of water, cement and aggregates
  - Proximity to buildings
  - Expansion and contraction joints
  - Exposure to ground moisture/chemicals
  - Existing ground conditions
- Where possible, it is recommended that a structural engineer is consulted to specify the required type, depth and layout of concrete for your specific requirement.
- In order to achieve a specified strength of concrete mix, you must use the correct ratio of fine aggregate, coarse aggregate, cement and water as specified in the charts.
- The water to cement ratio is important for the concrete to reach its specified design strength. Therefore, when ordering a concrete that has been designed to have a specified slump, it is important that you do not add water on site to improve workability as this will weaken the concrete and can cause failure.
- Concrete mixes are defined in ascending numbers starting at C6/8 and show the compressive strength of the concrete after 28 days. The smaller of the two numbers represents the compressive strength of a 150 by 300 mm length cylinder of concrete and the larger of the two numbers represents the compressive strength of a 150mm cube of concrete measured in newtons. When specifying strength, you may use the larger of the two numbers. (The target strength).
- In areas where it is considered that the concrete will be required to resist chemical attack from an aggressive soil, a DC class concrete will be required
- A structural concrete is one that has a compressive strength of more than 25 N/mm<sup>2</sup> and is generally intended to support vertical loads
- Maximum aggregate sizes may change depending upon the type of use for the concrete. Generally, a 40mm maximum size is used in mass fill scenarios. The most common maximum aggregate size is 20mm.

#### Concrete Categories

There are generally three categories of concrete,

#### **Standardised prescribed, designated and Proprietary.**

##### **Standardised prescribed concrete. (ST1 to ST5)**

- Standard prescribed concrete mixes are made using a prescribed quantity of materials as specified by British Standards. These are normally mixed on site or obtained from a ready mixed concrete company. As a site batched mix, their

strength cannot be guaranteed although an assumed strength can be made based upon those below

**Table of standard concretes**

<b>Mix</b>	<b>Assumed strength class</b>	<b>Slump class</b>	<b>Common use</b> <i>General non-structural applications</i>
ST1	C6/8	S1	kerb bedding, backing, drainage, haunching, blinding
ST2	C8/10	S2	trench-fill, kerb bedding, fence posts, drainage
ST3	C12/15	S3	Unreinforced oversites, kerbs, floor blinding, paving
ST4	C16/20	S2	Edgings and light unreinforced foundations, haunching, Paving, kerbs, shed bases

**Designated concretes**

- Designated concrete mixes are intended to simplify the specification process. Each of these has been categorised and is intended for a range of specific purposes. While they do not cover all, they are suitable for many structural applications and third-party product conformity certifications are met by the producer.

**All the mixes below fall into the category of designated concrete.**

**General (GEN) (GEN1 to GEN3)**

- Gen concretes are used for non-structural applications. The requirements specify a minimum amount of cement in the mix, but no water cement ratio (w/c) as such, they have relatively low levels of durability.

**Table of Gen Concretes**

<b>Mix</b>	<b>Min strength class</b>	<b>Slump class</b>	<b>Common use</b> <i>General non-structural applications</i>
Gen 00	C6/8	S3	kerbs, drainage, haunching and blinding.
Gen 01	C8/10	S3	trench-fill, kerbs, fence posts, kerb bedding, small wall foundations,
Gen 02	C12/15	S3	trench-fill, light duty bases, kerbs, floor blinding, paving, small wall foundations
Gen 03	C16/20	S3	Trench-fill, Edgings, haunching, un-reinforced strip footings Paving, kerbs, shed bases, small wall foundations

*Gen 00 to 03 should not be used externally unless completely encased*

**Reinforced concrete: RC20/25 RC23/30 RC28/35 RC35/45 RC40/50**

- RC concretes are used in concrete that will be reinforced, pre-stressed or contain embedded steel. The requirements specify maximum w/c ratio (W/C) and minimum cementitious content (MCC), which makes specification easier. Uses ranges from a lightly reinforced to agricultural reinforced concrete that is exposed to highly demanding exposure conditions.

**Table of reinforced concretes**

<b>Mix</b>	<b>Min strength class</b>	<b>Slump class</b>	<b>Common use</b> <i>Concrete that will be reinforced, pre-stressed or contain embedded steel</i>
RC20/25	c20/25	S3	Extremely mild exposure conditions, lightly reinforced garage floors
RC25/30	C25/30	S3	Mild exposure conditions, lightly reinforced concrete, reinforced foundations in DC-1 soils
RC28/35	C28/35	S3	Moderate exposure conditions, General reinforced concrete, garages and workshops
RC32/40	C35/40	S3	Moderate to high exposure conditions, general reinforced concrete, domestic garages
RC35/45	C35/40	S3	Highly demanding exposure conditions, industrial reinforced concrete, stable floors etc
RC40/50	C40/50	S3	Severe exposure conditions, agricultural and industrial reinforced concrete

### Paving concrete: Pav01, Pav02

- Pav concretes give the concrete the necessary level of freeze-thaw resistance for conditions experienced in the UK and are suitable for almost all external domestic and structural roads, pavements and hard standings.

**Table of Pav concretes**

<b>Mix</b>	<b>Min strength class</b>	<b>Slump class</b>	<b>Common use</b> <i>Freeze thaw resistant, domestic and structural roads, pavements and hard standings.</i>
Pav 01	c28/30	S3	Driveways, external paving, reinforced and un-reinforced hard standings
Pav02	C32/40	S3	Heavy duty external paving areas, Reinforced commercial use.

*Pav concrete should contain an air-entraining admixture giving a minimum air content of 4.0%, 4.5%, 5.5% or 6.5% by volume, with aggregate of 40 mm, 20 mm, 14 mm, and 10 mm maximum aggregate size respectively.*

### Foundation concrete: Fnd2 to Fnd4

- FND concretes are used in foundation applications where the ground has been found to contain sulphates. These have specified MCC and W/C and only employ cement types known to provide appropriate resistance to chemicals found in the ground

**Table of Foundation concretes**

<b>Mix</b>	<b>Min strength class</b>	<b>Slump class</b>	<b>Common use</b> <i>Foundation concrete for soils found to contain sulphates.</i>
FND2	C25/30	S3	All types of unreinforced foundations in DC2 soils.
FND3	C25/30	S3	All types of unreinforced foundations in DC3 soils.
FND4	25/30	S3	All types of unreinforced foundations in DC4 soils.

### **Site batched concrete using all-in ballast**

- Site batched concrete using all-in ballast that does not meet BS EN 12620 has no official strength rating as the proportion of fine and coarse aggregates in the mix cannot generally be guaranteed or measured. If using this method, it is essential that all in ballast complies to the British Standard and that the ratio of cement to ballast is accurately gauged in order to achieve a successful concrete mix.
- For general use concrete, it is advised that a mix of 6 parts all-in ballast to 1 part 32.5N cement should be used to create a concrete that is approximately c20 strength.

### **Proprietary concrete:**

- Proprietary concrete is designed by a concrete producer for a specific purpose or performance requirement. The composition is specific to the producer and they will offer a performance guarantee for the intended application. Proprietary concrete is used where high performance or specific properties are required.

## Concrete mixes

### Concrete Mix by weight

mix	Cement (kg)	Sand (kg)	Coarse Aggregate (kg)	Slump	Common use
St1 (C6/8)	230	770	1155	S1	Lean mix, blinding
St2 C8/10	265	760	1135	S2	Lean mix, step foundations, drainage works, trench filling, small non load bearing garden walls
St3 (C12/15)	295	745	1120	S2	Small walls, kerbs, floor blinding, paving, shed foundations
St4 (C16/20)	330	735	1100	S2	Edgings and light foundations, walls, haunching, Paving, kerbs
St5	375	720	1080	S2	Multi-purpose concrete, foundations and trench fill, kerbing, patio bases
C30	330	760	1050		Paving, external slabs, heavy duty oversite
C35	365	750	1030		Heavy concrete mix for reinforced footings and structural work

*General mix ratios for site batching using strength class 32.5 cement and 20mm maximum aggregate size. If using strength class 42.5 or higher, the cement weight should be decreased by 10 %.*

### Concrete Mix by volume

Cement strength class	mix	Cement (25 kg)	sand (Litres)	Coarse Aggregate (Litres)	Slump
32.5	St1	1	50	80	S1/ S2
	St2	1	45	65	S1/S2
		1	45	55	S3
	St3	1	40	55	S1/S2
1		35	50	S3	
42.5 or higher	St1	1	60	90	S1/S2
	St2	1	50	75	S1/S2
		1	50	65	S3
	St3	1	45	65	S1/s2
		1	40	55	S3

#### Water/cement ratio

- The water/cement ratio is the ratio of the weight of water to the weight of cement in the fresh concrete mix. The water/cement ratio controls the strength of the concrete and its permeability.
- There is an optimum water content for strength. Reducing water content from the optimum reduces strength and increases permeability. Increasing the water content from the optimum reduces strength and reduces permeability. It is important to remember that whilst adding more water to a mix improves its workability it also creates a weaker overall mix.
- The W/C Ratio varies from 0.4 to 0.7 depending on exposure conditions.
- 0.45 is average for concrete exposed to freeze/thawing.
- To calculate Water quantity for concrete, first, you must find the quantity of cement.

#### Calculation for the required water to cement ratio:

- Assuming the required cement volume is 50kg
- Required amount of water = W/C Ratio X Cement Volume
- Therefore, Required amount of water = 0.45 X 50 kg = 22.55 litres / 50 kg cement bag.

## Concrete Slump

- The 'slump', or consistence of concrete is measured in mm and refers to the consistency of fresh concrete before it sets. Each slump has a class rating, and this reflects the pliability of the mix. The higher the slump rating, the more fluid the concrete is.
- It is important to adhere to the slump. Adding more water to the mix to make it more pliable will also result in the target strength of the concrete not being met. Therefore, it is important not to request that the concrete delivered by a ready-mix supplier be made wetter in order to make it more workable.
- A slump test kit is very simple to use and relatively cheap to purchase and it is recommended that one should be used when site mixing concrete.

### Commonly used slump ratings and uses

Rating	Range	Target slump	Consistency of mix	use
<b>S1</b>	10 to 40	20	Semi dry	kerb and drain bedding
<b>S2</b>	50 to 90	70	damp	strip footings and bases
<b>S3</b>	100 to 150	130	wet	trench-filled foundations requiring high flowability

### Commonly used slump ratings and uses

Slump, mm	Water in kgs per cubic metre of concrete for given size of aggregate					
	9.5	12.5	19	25	37.5	50
<b>25 to 50</b>	207	199	190	179	166	154
<b>75 to 100</b>	228	216	205	193	181	169
<b>150 to 175</b>	243	228	216	202	190	178

## Movement joints

There are two main types of movement joint;

expansion/isolation/compressible and induced break/contraction.

## Expansion joints

- Allow expansion and contraction of a concrete slab or sand and cement mix without generating potentially damaging forces within the slab itself or the surrounding structures
- Joints consist of a complete gap between adjacent bays filled with a compressible material which spans from the bottom of the rigid construction to just below the finish surface. The remaining gap is then filled and sealed with a flexible sealant or similar.
- Are required at any point where the paving abuts an adjoining structure. The width of the expansion joint can generally be the same as the jointing space between the paving.
- As a rule of thumb, the allowance for expansion should be around 1mm per linear metre of rigid construction between the expansion joints. e.g., 6mm over 6 metres.
- Joints should always be installed at any geometric weak point such as paths turning a corner.
- There are multiple methods of determining concrete expansion joint type and spacing depending on strength, reinforcement, overall depth and geometry. The general rule for expansion joint spacing in concrete is based on 30 x the depth of concrete. with a maximum bay size of 6m and a maximum bay length to width ratio of 2:1 unless it is reinforced.

## Contraction joints

- Allow for contraction or shrinkage of a slab during the curing process.
- They are typically made up of a strip of DPC which spans from the bottom of the rigid construction to just below the finish surface. It can then be covered with matching jointing material.
- As a rule of thumb, the allowance for expansion should be around 1mm per linear metre of rigid construction between the expansion joints. e.g., 6mm over 6 metres.

## 5. Cement

cements are available in different strengths, generally 32.5 and 42.5N and various categories. They are chosen depending upon the task at hand. Below are some of the commonly used cements.

**Table of cement types**

<b>Cement type</b>	<b>use</b>
I	General purpose cement
II	Provides moderate resistance to sulfate attack
III	High early strength
IV	Low heat of hydration (not common)
V	Sulfate resistant
IA	Air entrained type 1 cement
IIA	Air entrained type 2 cement
IIIA	Air entrained type 3 cement

**6. Types of mortar mix and their classification**

- Sulphate resisting cement should always be used in exposed walls and areas that are of risk of considerable water movement such as earth retaining walls and where soils contain high levels of sulphate, i.e., London clay.
- Washing-up liquids and any additives containing calcium chloride should not be used as they can weaken the mortar and contribute to efflorescence staining.
- Proprietary jointing mortars may reduce the risks of cracking, staining, efflorescence, organic growth and frost damage. These can be a result of variations in weather, material gauging etc, during application of some sand/cement jointing mixes.

<b>Mix ratio masonry cement/sand</b>	<b>Mix ratio Cement/sand with air entrainer</b>	<b>Mix ratio cement lime/sand</b>	<b>B.S. class</b>	<b>Mortar strength n/mm<sup>2</sup></b>
	1: 3	1: 0.25: 3	1	M12
1: 2.5 to 3.5	1: 3 to 4	1: 0.5: 4 to 4.5	2	M6
1: 4 to 5	1: 5 to 6	1: 1: 5 to 6	3	M4
1: 5.5 to 6.5	1: 7 to 8	1: 2: 8 to 9	4	M2
1: 6.5 to 7	1: 8	1 :3: 10 to 12	5	

**7. Geotextiles.**

There are two main types of geotextiles, woven and non-woven, and they have different qualities and therefore different uses.

### **Woven Geotextiles.**

- Woven geotextiles have a higher load rating. As a result, they are generally used to reinforce and stabilise the structural layers, keeping each layer apart and maintaining the integrity of the structure. Without such a membrane, load stresses over time would force the granular stone layers into the softer soil, which cause failure.
- Whilst all geotextiles are permeable, woven does not filter water as well as non-woven.

### **Non-Woven Geotextiles.**

- Non-Woven geotextiles are generally used when a lesser load capacity is required.
- Non-woven geotextiles are excellent at allowing water to pass through whilst keeping fine particles of soil out.
- They are often used in the wrapping and protection of water attenuation crates and land drains and are utilised in permeable construction.

### **Geogrids**

- Polypropylene geogrids provide omni-axial reinforcement to granular sub-bases, and capping layers and are used in areas of weak & variable soils.
- When granular particles are compacted over these grids, they partially penetrate and project through the apertures to create a strong and positive interlock.

### **8. Admixtures.**

- There are several different types of admixtures that can be added to mortar to enhance workability and performance. All use of admixtures should be strictly controlled and in accordance with the manufacturers' instructions on dosage.
- Admixtures are used to retard the set of mortar when conditions require this or provide air entrainment to assist workability and prevent shrinkage within mortar joints.
- Air entrainment plasticisers are used to replace lime within the mix.
- Excessive use of admixture will have a negative effect on durability and weather-tightness due to increased porosity, especially when used in pointing mortar.
- Air entrainment additives should not be used in conjunction with masonry cements which already contain lime as a plasticiser.
- The use of hydrated lime in cement mortar has a number of benefits including:
  - Excellent workability, water retention within the mix, increased bond durability, flexibility and reduction in efflorescence
- Washing-up liquids and any additives containing calcium chloride should **not** be used as they can weaken the mortar and contribute to efflorescence staining.
- PVA may be used in pointing mix to further enhance its strength, binding and water proofing properties.

## 9. Bonding bridges or slurry primers.

- Commonly available as a ready-mix.
- Bonding bridge, slurry bond or primer is painted onto the underside of paving material to aid adhesion with the bedding layer.
- A priming mortar should always be applied to the cleaned and dust free underside of the paving unit and should be brush applied to enhance the bond and applied to the full area including the edges and corners.
- Bonding bridges should always be used with low porosity paving such as Slate and Porcelain to aid adhesion and with higher porosity stones such as some sandstones in order to help reduce the effect of wicking and efflorescence.
- It should always be used when laying over a permeable bedding layer in order to aid adhesion.
- The use of a bonding bridge in combination with a mortar that consists of white cement and a neutral-coloured sand which contains a low clay content, can help to prevent discolouration of the surface of light-coloured stones and limestone. This discoloration is a result of migration of naturally occurring elements within the sand and cement being drawn upward through the sub-base and bedding layers into the surface of the stone. This is commonly known as wicking.
- All primers should be removed from the surface of any paving immediately if spilled.

## 10. Types of bedding layer.

- It is a requirement of BS 7533 that paving bedding mortar be permeable to prevent moisture related issues such as frost damage.
- The permeability of hydraulically bound cement mixes and concrete will vary depending on their mix content. If the bedding material is more permeable than the base, this may result in a potential damaging effect to the surface material caused by wicking. In this case, the sub-grade should be free draining to prevent the base material from absorbing moisture and drawing it upwards toward the bedding material. If the subgrade is not free draining, then a sub-surface drainage system should be considered.

<b>type</b>	<b>Rigid</b>	<b>Non-rigid</b>	<b>Permeable</b>	<b>Very low permeability</b>
hydraulically bound sand/ cement mixes	yes			generally
Proprietary cementitious adhesives	yes			yes
exterior tile adhesives	yes			yes
Grit (crushed stone)		yes	yes	
Grit sand		yes	yes	
Proprietary permeable bedding material	yes		yes	

### 11. Types of jointing material.

- There are many forms of jointing material available. Unless otherwise stated by the designer, the choice of jointing material should reflect the permeability of base and laying course construction. Care should be taken to assess the quality of the product being used.
- Always take the time to read the installation instructions as certain products require minimum and maximum joint sizes and some products require a greater degree of finishing to achieve the required results.

**Table of jointing materials**

<b>Permeable jointing material:</b>	<b>Non-permeable or low porosity pointing materials:</b>
Polymeric sands	3:1 ratio sand/cement mortar
Grit (crushed stone)	Some two-part epoxy resins
Some two-part epoxy resins	Proprietary cement-based mortars
Kiln dried sand	Proprietary slurry mortars
Proprietary permeable cement-based mortars	

## 12. Kerbs and Edge restraints

- Edge restraints should be placed on a fresh Race of concrete or a Windrow.
- A Race is a strip of concrete of a consistent width and depth that generally extends from the sub grade, is placed in the required position and allowed to set. The edging restraint is then placed upon the race by means of class 1 mortar at a depth of no more than 25mm. These are commonly used in higher traffic categories or on driveway entrances where there are occasional heavy vehicles crossing the threshold.
- A Windrow is a strip of fresh concrete that is of a consistent width and depth that generally extends from the sub grade and is placed in the required position before the edge restraints being immediately placed directly upon the concrete. These are commonly used for edgings.
- In both instances, the base of the concrete should be at least 150mm wider than the edge restraint in order to accommodate the haunch on both sides of the restraint.
- The haunch should be of no less than 100mm wide at the base and should no less than half the height of the edge restraint and 60 mm lower than the surface.
- The concrete overhang at the front of the restraint should be angled to fall away from it.

### Intermediate restraints

- Intermediate restraints are generally used when paving a steeply sloped area. They are used to help reduce creep in the surface layer.
- The restraint can be a concrete Race or Windrush and incorporate the surface material.
- The distance between intermediate restraints should be even if using more than one and no more than 10 linear metres apart.
- If an intermediate restraint is being applied to a driveway that utilises a type c filtration system, provision will need to be made for drainage.

## 13. Drainage

After 1970, most homes were built with separate systems. One to carry wastewater to the mains sewer and one to carry rainwater and surface water out to a watercourse. These systems are designed to put less pressure on the mains system by preventing “clean” water mixing with “dirty” water. In this type of system, you might find stormwater gullies and foul water gullies around the property, as rainwater and greywater will have to discharge into separate drains. Discharge from outside taps, washing machines, etc. are classed as foul water in the grand scheme of things, but effluent from these appliances is more commonly known as greywater. This relatively clean wastewater can discharge into a wastewater gully without any issue but must not be allowed to flow into a rainwater/surface water drain. You should never connect a gully near a toilet outlet, as that type of wastewater needs to stay within a sealed system.

Vitrified clay is generally stronger and less likely to deform than the uPVC drainage, therefore uPVC drainage pipes should be surrounded by specific sizes of gravel. 110mm plastic pipes are more common in most domestic construction due to their ease of use but if the system is being shared by other discharge points, a 150mm pipe should be considered.

### Types of drainage gully

Drain type	Common use
hopper	A Fitting with an open top and an open base, the base opening is typically smaller than the top.
Gully	A fitting which has an open top, a definite base, and an outlet to one or more sides of the body of the gully.
Kitchen waste pickup (KWP)	A drainage fitting that collects waste or foul water from a kitchen sink, a dishwasher, washing machine or other outfall for grey water. It may be a gully, hopper or directly connected to the sub-surface drainage pipework.
Rainwater pickup (RWP)	a drainage fitting that takes surface water from a roof downspout or collects surface water. It may be a gully, hopper or directly connected to the sub-surface drainage pipework.
Bottle Gully, Compact Gully or Universal Gully	Most gullies of this type are trapped, often by means of a baffle plate that is removable in some models.

### Drainage pipe

Vitrified clay is generally stronger and less likely to deform than the plastic drainage, therefore plastic drainage pipes should be surrounded by specific sizes of gravel. 110mm plastic pipes are more common in most domestic construction due to their ease of use but if the system is being shared by other in a combined drainage system (as with many pre-1970 properties, wastewater, stormwater and surface water are generally discharged into one drainage system and deposited in a single destination. With this type of system, you tend to see external greywater waste pipes discharging into the same gully as the rainwater downspout.

## Bedding, side fill and backfill

- The material used to backfill around the drainage should be free from stones larger than 40mm, lumps of clay greater than 100mm, timber, organic matter or any frozen material.

### Specification for bedding and backfill material

Pipe diameter (mm)	Maximum particle size (mm)	Recommended bedding material
100	10	5 to 10 mm graded or 10 mm single sized
100 to 150	15	10 or 14mm single sized. or 14-15mm graded
150 to 300	20	10/14/20mm single size, 14-5mm graded or 20-5mm graded

## 14. Surfacing types and considerations

### Grass reinforcement

- Plastic or concrete reinforcement grid systems that are infilled with grass or gravel.
- The surfacing provides very little contribution to the load-bearing capacity of the pavement structure
- Often used with normal Type 1 sub-base below (not for water storage)
- Where used with coarse-graded aggregate sub-base, a geotextile will be required between the sand bedding/ growing layer and the sub-base, otherwise the sand will be washed down into the sub-base
- **Porous asphalt or macadam**
- Used in SuDS driveway construction design in conjunction with a permeable type 3 sub-base.
- Maintenance of the surface should be considered in order that the pores of the surface do not get blocked over time and reduce the effectiveness of the surface drainage.

- **Resin bound aggregate**
- Generally used with SuDS driveway construction design in conjunction with a type 3 sub-base.
- If being used over a bound, non-permeable sub-base, consideration should be made to the level of any surface drainage channels. Surface water may also build up in the bound material and freeze in the winter causing long term damage to the surface and a slippery surface.
- **Resin bonded aggregate**
- Used in conjunction with a bound base.
- Any expansion/contraction joints in the base should be extended to the surface of the resin bonded material. This should be taken into account during the design of the driveway
- **Loose gravel**
- Used with either SuDS driveway construction or semi-permeable construction.
- It is important to note that when using type 1 sub-base material, the construction is not considered permeable.
- **Concrete**
- Concrete driveways may be permeable or non-permeable.
- Porous concrete is a specialist product and advice should be sought from the manufacturer regarding specifications.
- 
- **Concrete block paving**
- Used with either SuDS infiltration construction or surface drainage design.
- The use of Standard driveway blocks and /or type 1 sub-base material will not be considered a permeable construction.
- Block paving is not suitable for steep driveways as the infill material is susceptible to being washed away in heavy rain.
- **Natural stone cobbles and setts**
- Cobbles and setts can be used in a Suds permeable construction when laid on proprietary permeable bedding mortar and jointing material. Permeable construction is a good option when using roll topped reclaimed material as it removes moisture from the surface very efficiently.

## 16. Process

Before approaching a project, ensure that you are fully aware of your responsibilities regarding CDM regulations and SuDS regulations. More information can be found below:

### **Construction (Design and Management) Regulations 2015.**

[www.hse.gov.uk/construction/cdm/2015/index.htm](http://www.hse.gov.uk/construction/cdm/2015/index.htm)

**Excellent resources for construction specification can be found below.**

## **Building regulations Part H drainage and waste disposal**

[www.labc.co.uk/sites/default/files/content/br\\_pdf\\_ad\\_h\\_2015\\_0.pdf](http://www.labc.co.uk/sites/default/files/content/br_pdf_ad_h_2015_0.pdf)

### **Details of SuDS regulations**

[www.susdrain.org/resources/SuDS\\_Manual.html](http://www.susdrain.org/resources/SuDS_Manual.html)

[www.paving.org.uk](http://www.paving.org.uk)

### **Construction design specification**

[www.bsigroup.com](http://www.bsigroup.com)

### **Information on roadway construction**

[www.standardsforhighways.co.uk/ha/standards/mchw/vol1/pdfs/MCHW-vol-1-Series-800.pdf](http://www.standardsforhighways.co.uk/ha/standards/mchw/vol1/pdfs/MCHW-vol-1-Series-800.pdf)

#### **17. Basic preconstruction checklist**

1. Client(s) and/or designer scope of works signed off
2. Client(s) /contractor contract agreed and signed by both parties
3. CDM principal agreement agreed and signed off by all parties.  
(Including scope of works, timelines, client responsibilities etc).  
(Confirm and agree access, any security arrangements and any restricted working times with all parties)
4. (Does the client require specific property insurance for the duration of the works?)
5. Materials procurement and relevant documents acquired and agreed by all parties
6. Initial visual property inspection results agreed and signed off by all parties
7. provide and agree a construction Specification and timeline with all parties
8. check if there are any specific local authority requirements for the proposed construction
9. carry out inspection for services and record results
10. carry out site subgrade inspection for strength and permeability and record results
11. carry out soakaway suitability test and record results (if using a soakaway)
12. if any changes will be required to the initial proposed scheme, then hold the works, consult all relevant parties and agree and sign off on a new scope of works.
13. If all is suitable and agreed, commence works.

## Inspection test plan

- In order to aid project logistics and process, It may be helpful to employ the use of an inspection test plan (ITP) An ITP encompasses much of the required paperwork for a project such as the scope of works and construction phase plan into one document, along with the plan for managing the quality control and assurance of each element of the works, providing information on the requirements, an overview of the method(s) to be used, responsibilities of relevant parties, and documentary evidence to be provided to verify compliance.
- Within the ITP, the use of hold points is useful. These are a series of points at which the project does not move forward until a certain critical part of the process has been completed, checked and signed off.

## 18. Design

### Considerations

- Before commencing any works, a survey should be made to determine the presence and depth of any existing services.
- A soil test should be carried out to determine the condition and depth of the sub-grade.
- A percolation test should be carried out to determine the permeability of the sub-grade.
- The trafficking category of the driveway should be determined in order to correctly specify the required foundation of the driveway.
- If the driveway is narrow and the vehicle will follow the same track repeatedly, there is heightened potential increased risk of deformation of the surface.
- If the driveway is on a curve and/or at a steep angle, there is a potential for an increased level of stress to be placed on the entrance to driveway. In this case, a rumble strip is useful.
- Any soakaway should be a minimum of 5 metres away from the house or a road and 2.5 metres away from any boundary.
- For SuDS infiltration Systems A and B, the highest recorded groundwater level must not be greater than 1000mm below the bottom of the permeable sub-base.
- Existing tree roots or invasive plants should be considered during the design phase of the driveway and provision made for dealing with root structure. Large roots will very likely cause damage to the construction. Also, the construction may cause damage to the roots.
- If the drive is steeply sloping (greater than 1 in 20) it may not be suitable for permeable surfacing. In such cases an impermeable surface may be used and if possible, the water directed to a soakaway.
- When using block paving on a steeply sloped driveway, there is an increased risk of scour. This is when the movement of water over the surface removes sand from the joints. In this case it may be worth considering an alternative surface.
- Permeable pavements infiltrate water into the ground at much shallower depths than traditional soakaways. Generally, the percolation tests for these are much

shallower (less than 1m depth) and use a lower head of water, to replicate the performance of the permeable driveway.

- If considering rainwater harvesting, the water can only be used for a range of non-potable uses and needs to be free of debris and sediments. Permeable driveways will help to achieve this. The storage volume for reuse should be separate to that for rainfall attenuation. This is because the two types of storage have different requirements:
- Rainwater reuse – should be full for as much of the time as possible so that water is available for use.
- Storm water attenuation – should be empty most of the time to temporarily store water from rainfall.
- Construction should not be carried out if any of the construction materials are waterlogged and/or frozen.

### **Planning Permission**

- Planning permission will be required to pave an area greater than 5m<sup>2</sup> with an impermeable surface if it does not provide run-off to a permeable area or soakaway.
- Planning permission to pave a new or existing driveway of any size may not be required if a SuDS permeable (or porous) construction is applied, in this case, the rainwater must be directed to a soakaway or provision made for the water to may naturally within the boundary of the property.
- There are national and regional regulations so please refer to the relevant guidance.

## **19. Subgrade strength and permeability**

### **Trial holes**

- A minimum of two trial holes should be excavated across the site to assess the firmness and permeability of the sub-grade. The trial holes should be placed at intervals of no more than 50 square metres apart and should include the lowest elevation of the site. The hole depth should be that of the proposed overall construction. If loose soil or unexpected material is found at the base of the hole then it should be excavated further to determine the condition and level of the sub-grade. The maximum depth of the hole should be no more than 500mm. If a suitable sub-grade is not found within this depth, an engineered design should be made in accordance with BS7533-101

### **Subgrade assessment**

- An assessment of the subgrade should be made in order to determine its ability to support the construction. If a CBR test is not available, the following estimated values may be used.

**Table of subgrade types**

Soil type	Plasticity index %	Low water table			High water table		
		Construction conditions			Construction conditions		
		Poor	average	good	Poor	average	good
Heavy clay	70	1.5	2	2	1.5	2	2
	60	1.5	2	2	1.5	2	2
	50	2	2	2	1.5	2	2
	40	2.5	3	3	2	2.5	2.5
Silty clay	30	3	4	4	2.5	3	3.5
Sandy clay	20	3	4	4	2.5	4	4.5
silt	10	1	2	2	1.5	3	3.5
Poorly graded sand	n/a	20					
Well graded sand	n/a	40					
Well graded sandy gravel	n/a	60					

- Care should be taken when evaluating subgrade values during summer as the dryness of the soil may provide artificially high values.
- Subgrade values below 2% will require improvement by applying a capping layer or replacement prior to application of the foundation material.

**Foundation thickness**

Subgrade CBR design value							
	2.5%	3%	4%	5%	10%	15%	30%
No commercial traffic	170	150	150	150	150	150	150
Potential commercial traffic	240	220	210	180	150	150	150

*For subgrades with a CBR less than 2.5% a sub-base on capping design is required.*

*A capping layer is made up of well compressed, non-frost susceptible unbound aggregate that is used to improve the performance of the subgrade before laying the sub-base. This may be type 1 or type 3 aggregate.*

### Sub-base over capping design

Subgrade cbr design value								
	2.0%	2.5%	3%	4%	5%	10%	15%	30%
No commercial traffic	150/150	150/150	150/150	160/0	150/0	150/0	150/0	150/0
Potential commercial traffic	150/370	150/250	150/170	150/160	150/150	150/150	150/0	150/0

*Values should be read as sub-base/capping depth.*

#### Basic footprint test

- A useful way to assess the stiffness of the sub-grade is to use the footprint test. Once the sub-grade has been exposed, it should be firmly trodden upon with a standard safety boot. If a print of 2mm or less is formed, then the sub-grade firmness is considered adequate. If a print of 2 to 4mm is formed, then a minimum of 100mm of sub-base material should be added. If a print of more than 4 mm is formed, then a design should be made in accordance with BS7533-101. This test should be repeated over the whole site once excavated to ensure there are no soft spots in the sub-grade.

#### Porosity and permeability

- Porosity refers to the amount of empty space or “pores” within a material and is directly related to the amount of water it can hold.
- Permeability refers to how efficiently water flows through the material. This is affected by how well the pore spaces are connected.

#### Sub grade permeability

- A simple test may be used to assess the permeability of the sub-grade.
- A further hole should be excavated in bottom of the trial holes, to a depth of 30mm. The hole should then be filled with water and a timer set for 10 minutes. If the hole has completely drained within the allotted time, this will be considered adequate sub-grade drainage.
- This rate of percolation is  $5 \times 10^{-5} \text{m/s}$ , which is the equivalent to the 3mm per minute. If the sub grade does not meet the required rate of percolation, a sub-surface drainage system should be installed above the sub-grade.

The official method of carrying out a percolation test is Percolation Test is as follows:

- Dig a 300mm square hole to a depth of 300mm below the proposed invert level of the soakaway.
- Fill the hole with water and allow it to seep away overnight.
- Refill the hole with water the next day and time how long it takes for the water to seep away from 75% full to 25% full.
- Divide this time by 150. If the resulting number is between 12 and 100, the ground is suitable.
- Do not carry out the test during heavy rain, severe frost, or drought.

### permeability of soils

- Soil permeability is a measure of the capacity of the soil or rock to allow water to pass through it. It is represented by the permeability coefficient (K) The table below will give an indication of these values for different soils.

**Typical values of permeability of soils**

Soil type	Coefficient of permeability. k	Drainage properties
Clean gravel	10 <sup>+1</sup> to 10 <sup>+2</sup>	Very good
Medium and coarse sands	10 <sup>-2</sup> to 10 <sup>+1</sup>	good
Loose silt, fine sands	10 <sup>-4</sup> to 10 <sup>-2</sup>	fair
Dense silt, clayey silts	10 <sup>-5</sup> to 10 <sup>-4</sup>	poor
Silty clay, clay	10 <sup>-8</sup> to 10 <sup>-5</sup>	Very poor
Heavy clay, silty clay	10 <sup>-10</sup> to 10 <sup>-8</sup>	negligible

### Presence of ground water

- If ground water is found to be present during excavation of the trial holes, a sub-surface drainage system should be installed above the sub-grade.

### Frost susceptibility

- It is important to understand what type of soil you are dealing with as Some soils are more susceptible to frost than others. This can cause heave which, in turn can cause movement in the foundation of the construction.

**Table of frost susceptibility of soils**

<b>Soil type</b>	<b>Frost susceptibility</b>
Low plasticity clay, silts, clayey and silty sands and gravels	high
Medium and high plasticity clays	Medium
Clean sands and gravels	low

*Well-drained soils where the water table is well below the construction are less likely to be damaged by frost*

## 20. Drainage

- Surface water drainage should discharge to a soakaway or other infiltration system where possible. If other forms of outlet are not possible, discharge should be made to a sewer. (Local authority permission should be sought before works commence.)
- You may not drain surface water on to a neighbour's property.
- Before the drainage type is decided upon, you should calculate the expected volume and rate of surface water that is to be drained from the driveway. This may dictate which type of drainage system to install.
- The finished level of the paving should be between 4mm and 8 mm above the top surface of any gulley, drainage inlet or drainage channels.

### Surface run off calculation

- In order to calculate the volume and rate of surface water discharge, you should use the calculation below.

The run-off capacity (Q) measured in litres per second =

The size of area being drained (A m<sup>2</sup>) times the rainfall rate (r mm/hr) divided by 3600

$$Q = (A \times r) / 3600$$

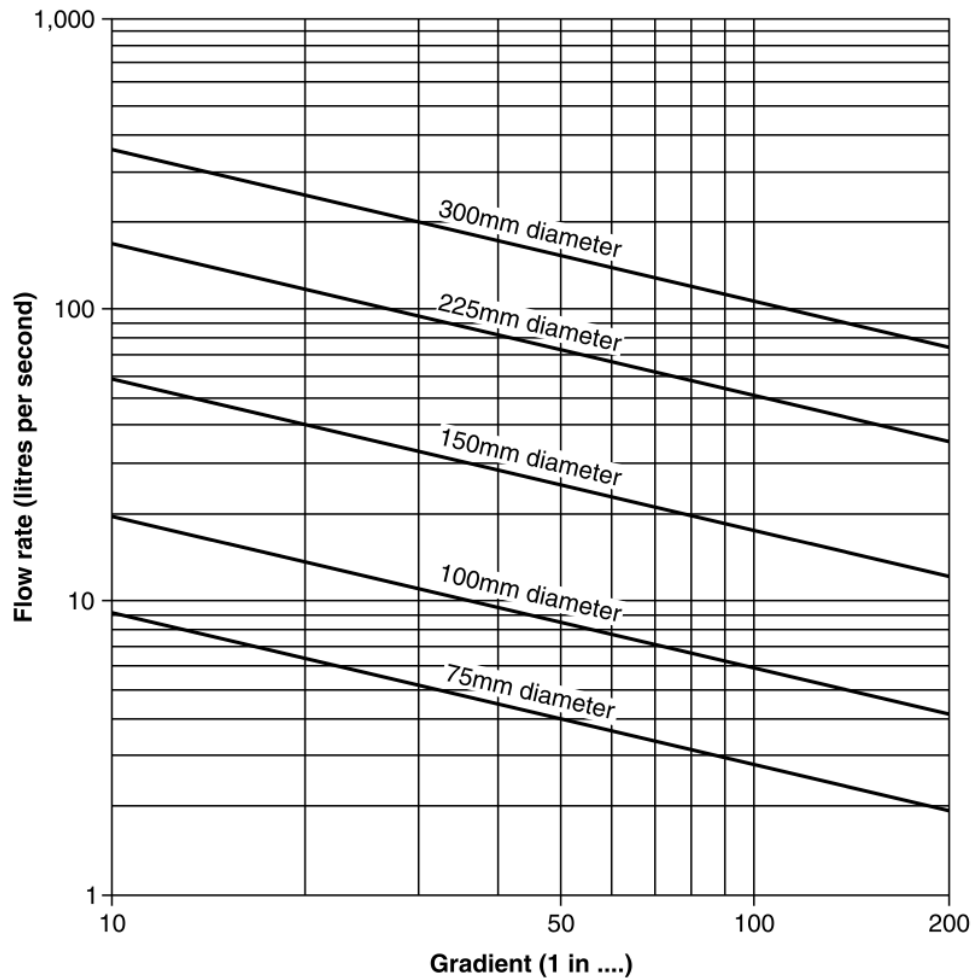
In the UK, a typical rainfall intensity rate (r) of 75mm per hour is used.

Example for a driveway of 100 square metres:

$$Q = 100 \times 75 / 3600$$

$$Q = 2.08 \text{ litres per second}$$

The size of drainage pipe and its fall will determine the flow rate of the discharge, and this can be calculated using the table below.



- For 100mm pipes, the minimum fall is 1:100 for Surface Water.
- The number of drainage points required for any given area is determined by the maximum flow rate of the pipework.
- Generally, a gully which is served by 100mm pipework to a minimum 1:100 fall will drain an area of no greater than 200m<sup>2</sup>
- if planning to use an existing gully or other drainage point to drain a new or extended driveway, allowance should be made for any existing service utilising that gully for drainage.

### Drainage systems

- **SUDS Sustainable drainage systems**
- Sustainable infiltration drainage systems (SuDS) are designed to manage the discharge of stormwater as close its source as possible, to mimic natural drainage and encourage its infiltration, attenuation and passive treatment.
- SuDS compliant schemes reduce pollutants in the water, such as hydrocarbons, nutrients and heavy metals, by filtering and treating runoff. This ensures that the

water soaking into the ground and discharging to nearby watercourses or sewers is cleaner, protecting water quality and wildlife.

- According to the CIRIA SuDS Manual, there are three best-practice applications for permeable driveways. These may incorporate gravel, permeable concrete, permeable asphalt and resin bound aggregate over a permeable asphalt surface.

## **Permeable infiltration Construction Systems**

### **System A-Full infiltration (zero discharge)**

- This system allows all water falling onto the driveway to permeate the surface layer, pass through the lower permeable courses and into a free draining subgrade. Some water may be retained within the attenuation reservoir before permeating the subgrade. Full infiltration systems do not discharge any additional water into traditional drainage systems although provision for the attenuation of excess stormwater via a soakaway would be worthy of consideration.

### **System B-Partial infiltration**

- This system is typically used where the sub-grade is not capable of draining all the water from the site. Outlet pipes are installed above the formation level within the sub-base and/or base layer in order to allow any excess water that cannot penetrate the subgrade to be discharged into other drainage devices such as watercourses, swales or sewers.

### **System C-Full attenuation**

- This system is typically adopted where water recycling is desired, in areas where water may be contaminated, or where the sub-grade is impermeable or becomes weak when saturated. The system includes an impermeable membrane above the sub-grade and outlet pipes within the sub-base layer. Full attenuation systems allow water to be captured and re-used in non-potable applications such as irrigation or flushing toilets. (Also known as “grey water”).
- There are various permeable sub-base replacement systems available that can be incorporated into permeable driveways. Generally consisting of plastic, cellular units called attenuation crates, connected to form a raft structure that replaces some or all the permeable sub-base. These systems have specific requirements regarding vehicular loading and specialist advice should be sought before application.

## Alternative drainage systems

### French or filter drains

- The French drain is a very simple solution that can be very effective on smaller projects.
- This form of drainage assumes free draining sub grade and that the driveway will be drained with a cross fall.
- A small trench of approximately 300mm wide and 600mm depth is excavated alongside the driveway, set back from the edge restraint haunching. The trench is lined with non-woven geotextile. A perforated drain is placed in the bottom of the trench. The trench is then filled with rounded 10 or 20mm gravel to a finished level of approximately 100mm below the finished surface. The geotextile is folded over the top of the gravel and the trench is then covered with free draining material to finished height.

### Channel, linear or slot drains

- linear systems that incorporate a channel together with an inlet detail that is embedded in the constructed surface.
- The channel is longer than it is wide and the channel body can be manufactured from Polymer Concrete, Plastic or Steel.
- The embedded inlet (grating) detail may be cast iron, steel or polymer composite gratings through to 'slot' that can barely be seen.
- Both the channel and the gratings have a load rating and if using mis matched load bearing channels and gratings, you should assume the lesser of the values for strength purposes.
- A gully or trap should be installed at the end of the drainage run in order to catch any material that may affect the efficiency of the soakaway.

#### Linear drain class rating

Class rating	Test load	Common use
A	15kN	Pedestrian and cyclist
b	125kN	Car parks, residential driveways
c	250kN	Small commercial car parks

### Rain Gardens and Swales

Other drainage options for small driveways may be rain gardens or swales. Due to the nature of raingardens, they may only be suitable for larger driveways when the subgrade is free draining. In some cases, a rainwater garden overflow may be connected to the main drainage system, but permission must be sought from the local authority.

A rain garden is a shallow depression, with absorbent, yet free draining soil and planted with planting that can withstand occasional temporary flooding.

- A rain garden typically comprises of the following features:

#### **Surface level /Freeboard**

- The freeboard provides potential water storage space, above the topsoil. The freeboard depth is measured from the carriageway or footpath level to the top of the topsoil.
- The freeboard should be 200-300mm deep to encourage water to flow into your rain garden and to accommodate silt accumulation and leaf litter., where the topsoil is level with the footpath or carriageway, which does not allow water to flow into the rain garden. The minimum freeboard depth should be 100mm.

#### **Base layer /Topsoil**

- Topsoil be a mixture of soil, sand and compost. Soil permeability can be specified according to the ratio of these three components. Rain gardens often have a sandier soil composition than normal to allow faster infiltration. A ratio of approximately 50% sand, 30% topsoil and 20% compost will be suitable for most plants, although not all plants cope well in sandy soil conditions.
- A minimum depth of 300mm of topsoil is recommended for shrubs and herbaceous plants. A shallower depth of 200mm can be considered for rain gardens that will be turfed or seeded with wildflowers.
- You should seek advice from a horticulturist, landscape architect or grounds maintenance specialist when specifying your topsoil.
- A layer of mulch should be added to planted rain gardens to help suppress weeds and reduce competition for water and nutrients whilst the planting becomes established.

#### **Sub-base/storage layer**

- The sub-base should be 100-500mm deep.
- The depth of sub-base will vary depending on the required storage capacity. A deeper sub-base will help store more water. Typically, the sub-base will be 100-500mm deep, and a minimum depth of 100mm is recommended in most instances. In the instance where the sub-soil is free draining, or the catchment area is small it may be considered appropriate to eliminate the sub-base layer entirely.

To determine how much rainfall the rain garden can store the following two simple calculations should be carried out:

- **The Volume of rainfall (m<sup>3</sup>)** = The Depth Of Rainfall (m) x The Catchment Area (m<sup>2</sup>)
- **Volume of Storage (m<sup>3</sup>)** = Depth of Storage in rain garden (m) X The Area Of The Rain Garden (m<sup>2</sup>)
- The storage depth is a combination of the freeboard and the sub-base storage.
- **Depth of Storage (m)** = Depth of Freeboard +30% of Sub-base depth (m)
- Only 30% of the depth of sub-base is used because this is the typical porosity of the gravel layer. For a given design standard, if the Volume of Storage is greater than the Volume of Rainfall it can be assumed that the Design Standard has been achieved.

For example.

Area of Rain Garden = 20m<sup>2</sup>    Catchment Area = 100m<sup>2</sup>    Depth of Freeboard = 0.1m,  
Depth of Sub-base = 0.45m

$$\begin{aligned}\text{Depth of Storage (m)} &= \text{Depth of Freeboard} + 30 \% \text{ Depth of Sub-base} \\ &= 0.1 + 30\% \text{ of } 0.45\text{m} = 0.25\text{m}\end{aligned}$$

$$\begin{aligned}\text{Volume of Storage (m}^2\text{)} &= \text{Depth of Storage} \times \text{Area of Rain Garden} \\ &= 0.25\text{m} \times 20\text{m}^2 = 5\text{m}^2\end{aligned}$$

**Advice on the design and construction of rain gardens can be found on the websites below:**

[www.raingardens.info](http://www.raingardens.info)

[https://www.urbandesignlondon.com/documents/85/UDL\\_Rain\\_Gardens\\_for\\_web\\_0vwx1L\\_s.pdf](https://www.urbandesignlondon.com/documents/85/UDL_Rain_Gardens_for_web_0vwx1L_s.pdf)

## Surface falls and drainage

Paving type	Recommended minimum fall
Coarse-textured paving units	1:60
Fine-textured paving units and porcelain	1:60
Drainage channels	1:80
steps	1:60
Concrete block paving	1:80

*Coarse textured paving units are cleft or riven stone, or profiled concrete paving units.*

*Fine textured paving units have a plane surface.*

## 21. Soakaways

- A soakaway is an infiltration system that is used to disperse storm water collected from the driveway into the sub-soil. A soakaway will only be effective in permeable sub-soils. If this is not the case, you must seek an alternative drainage solution.

### Soakaway position

- It must be in a position lower than the area being drained
- It must be at least 5m away from any building and 2.5 metres away from any boundary.
- It must be sited so that it will not saturate the foundations of any structure.
- Its base must be permanently above the water table
- It must be far enough away from other soakaways/infiltration devices so as not to impair its function.
- It must be sited so that there is no risk of contamination from pollutants

### Soakaway suitability

- To determine if the site will be suitable for a soakaway, you should first determine the level of the water table.
- The water table should not be within 1.2 metres of the bottom of the proposed invert pipe.
- A trial pit should be excavated to a depth of at least 1.2 metres below the bottom of the proposed drainage invert. The width of the excavation at this stage could be that which can be worked in comfortably. (Ensure that you follow health and safety guidelines regarding shoring and isolation of the excavation).
- Cover and secure the excavation and leave for 24 hours.
- After 24 hours, inspect the excavation, if no water is present, then it will be suitable. If it contains water to a height of within less than 1.2 metres of the invert level, then

it will not be suitable for a soakaway and another means of drainage should be sought.

- Groundwater levels will differ at different times of year, and this should also be taken into account.
- In order to determine if the water table is too high during the winter you may look to see if you can identify a mottled brown/grey tide mark. If this is present within 1.2 metres of the drainage invert, then an alternative solution will be required.
- Once the non-presence of water table has been established, the next step is to carry out a percolation test to assess the permeability of the soil.

#### Percolation test

- A test pit of 300 mm square and 300mm deep should be excavated in the bottom of the soakaway pit. This should then be filled with water and allowed to drain for 12 hrs.
- Place a nail into the side wall of the trial pit or some form of mark at 75mm from the top and 75mm from the bottom.
- Fill the hole with water and time how quickly the water drains between the two marks.
- This time should then be divided by 150 and this will give the rate of percolation. A number under 100 will mean that the percolation rate is good and the site will be suitable for a soakaway.
- This test should be repeated twice to ensure consistency.

#### Soakaway size

- Once the suitability of the subgrade permeability has been established, the calculation for the required storage capacity for the soakaway should be made. The following formula states that the volume of soakaway required is equal to the area to be drained (in m<sup>2</sup>) multiplied by the product of the storm rainfall rate. The assumed rainfall rate is 50mm/hr in the UK. This is then divided by 3000.

$$\text{Vol} = A \times (\text{rainfall rate}/3000)$$

Therefore, if the area to be drained is 50 square metres, vol = 50 x50/3000= 0.83m<sup>3</sup>

- This is the amount of **clear storage volume** required between the base of the soakaway (or water table if present) and the bottom of the invert of the drainage.
- If back filling the soakaway with loose material, an adjustment will have to be made in order to retain this storage capacity. Any loose fill material should be clean, well graded and non-frost susceptible.
- It is advisable to install preformed drainage structures as these are rated for strength and have a clear volume capacity.
- If the soakaway is to be load bearing, it should be capped using steel reinforced concrete to a depth of 150mm and the concrete should extend past the excavation by a minimum of 250mm.
- If the soakaway is not to be load bearing, it may be capped with a suitable membrane to ensure

## **Formation level**

- Once the correct subgrade firmness and permeability have been confirmed, the exposed level may be considered as the formation level. This will be the initial layer from which construction will begin

## **Bound and unbound construction definition**

### **Unbound construction**

- Unbound construction can be an unbound surface course laid over an unbound or bound base

### **Bound construction**

#### Bound system A

- A bound surface course laid over a hydraulically bound material or an unbound base layer, to which the bedding mortar is not adhered. This system should be used only for setts and pavers having depth not less than width or relatively thick slabs and flags in areas of traffic category 4 and below.

#### Bound system B

- A bound surface course bonded to a concrete base.

## **Bound, unbound, permeable and impermeable**

- It is often thought that bound construction is non-permeable and unbound construction is permeable. This is not the case. It is possible to create a permeable bound construction using proprietary permeable mortars in combination with either porous concrete, permeable bitumen or a combination of reinforced concrete and 45mm drainage pipes at regular intervals that extend to the sub-base. This type of construction should be coupled with a permeable type 3 sub-base material. A type 1 material is not considered to be fully permeable.
- It is also possible to create a non-permeable construction with a combination of cementitious bedding mortar and non-porous jointing material.
- It is important to ensure that the combination of construction materials reflects the required permeability of the proposed design.

## **Traffic categories**

- Generally, a domestic driveway will fall into trafficking category 3 or below.
- These categories determine the specification for the sub-base depth and material and are dependent upon the use of the driveway.

- Once the category has been established, the type and depth of subbase, material can be selected from the relevant tables in this document.
- If it is believed that the driveway will fall into category 4 or above and will receive regular visits from heavy vehicular traffic, a design should be provided in accordance with BS 7533-101

#### unbound construction

Traffic category	Cumulative standard axles	Road category	Typical applications
3	0	n/a	Small car parks subject to car, light van and motorcycle access
2	0	n/a	Pedestrian and cycle areas, domestic driveways
1	0	n/a	Pedestrian only areas, including domestic applications

#### Bound Construction

Traffic category	standard axles per day	Typical applications
3	0	Small car parks subject to car, light van and motorcycle access
2	0	Pedestrian and cycle areas, domestic driveways
1	0	Pedestrian only areas, including domestic applications

#### Construction layers

##### Definition and order

- There are six potential levels of material involved with construction. The requirement for each should be determined before construction begins. If unsure, you should seek the advice of a civil or structural engineer.

### **The Capping layer.**

- Used when the existing sub-grade requires stabilisation or improvement. The material used for this layer should be non-frost susceptible and is generally made up of well compacted type 1 or type 3 material.

### **The Geotextile membrane**

- Generally applied at formation level and used to aid stabilization of the sub grade and to prevent the migration of construction materials into the previous construction level.

### **Base**

- The base is the load-bearing layer immediately below the bedding layer or laying course and serves to provide strength and support to the overlying pavement. In many cases, this is the first layer of foundation. This layer may be rigid or flexible.
- One of the following base materials should be used.
- Non permeable Unbound base material should be Type 1 unbound granular material
- permeable Unbound base material should be Type 3 unbound granular material
- Cement bound granular material (CBGM) base should be CBGM conforming to
- BS EN 14227-1:2013, strength class 8/10.
- Concrete base should be pavement quality concrete with a minimum compressive strength class of C20/25.
- Bituminous base should be constructed from one or more of the following materials:
- AC 20 dense bin 100/150 rec
- AC 20 open bin 100/150 rec
- AC 32 dense base 100/150 rec
- Porous asphalts might be particularly useful where improved base permeability is sought whilst maintaining structural integrity.

### **Sub-base**

- The sub-base lies below the base and serves as the foundation for the overall pavement structure, transmitting traffic loads to the subgrade while providing drainage and frost protection.
- This layer is generally flexible. The quality of subbase is very important for the lifespan and effectiveness of the construction and can outlive the life of the surface.
- Sub-base material should be Type 1 unbound granular material.

*The sub-base and base may be made up of two separate types of material or of one material*

### **Bedding or laying course.**

- The layer upon which the final surface course will be laid. It may be bound or unbound, (rigid or flexible) and permeable or impermeable depending on the

required use and permeability of the overall structure and any future considerations for access to utilities. The permeability of the bedding or laying course is not related to being bound or unbound.

- At this point, in the case of a gravel driveway you may consider the use of gravel retention grids placed upon the base.

### Surface course

- Great care should be taken when considering the type of surface course, aesthetic choices should be secondary to practical ones, especially on steep driveways.

## 27. Typical base thicknesses for paving types

Concrete blocks, clay pavers and unbound sawn-sided stone setts

**Table of sub-base/base thickness**

Traffic cat	Min base thickness (mm)						Min concrete/sandstone paving unit thickness		Min clay paviour thickness	
	Unbound surface			Bound surface			Un bound	bound	Un bound	bound
	Unbound base	Bitumen base	cbgm base	Unbound base	Bitumen base	Concrete base				
3	100	n/a	n/a	n/a(A)	150 (D)	100©	50	50	65	50
2	100	n/a	n/a	100	80(B)	100(B)	50	50	50	50
1	100	n/a	n/a	75	60(B)	100(B)	50	50	40	30

- (A) bound base is considered necessary for an unbound surface or a bound surface course.
- (B) Surface construction Bound system A.
- (C) Surface construction Bound system B.
- (D) Bituminous base is only acceptable with Bound System A.

## 28. Compaction rates

Considerations

- It should be ensured that the correct amount of compaction is placed upon the sub-base material once it is laid.
- The sub-bas material should not be so dry as for the fines to be made airborne upon compaction as this may result in failure of the base. If this is the case, a misting of water may be applied whilst compacting.
- The sub-base material should not be compacted if it is sodden or frozen as this may also result in failure.

- Passes should be alternately longitudinal and transverse in direction and each run should overlap the previous by half. One pass equates to full coverage of the site.
- The recommended minimum centrifugal force requirement for a plate compactor in driveway construction is 35 kn.

**Table of Compaction rates**

Type of compaction plant	category	Number of passes for layers not exceeding the following compacted thickness.		
		110mm	150mm	225mm
Smooth wheeled roller (vibratory roller without vibration)	Mass per metre width of roll			
	Over 2700 kg up to 5400kg	16	Unsuitable	Unsuitable
	Over 5400kg	8	16	unsuitable
Vibrating roller	Mass per metre width of vibrating roll			
	701 kg up to 1300 kg	16	unsuitable	unsuitable
	1301kg up to 1800 kg	6	16	unsuitable
	1801 kg up to 2300 kg	4	6	1
	2301 kg up to 2900 kg	3	5	9
	2901 kg up to 3600 kg	3	3	8
	3601 kg up to 4300 kg	2	4	7
	4301 kg up to 5000 kg	2	4	6
	over 5000 kg	2	3	5
Vibro-tamper	Mass			
	Over 50 kg to 65 kg	4	8	unsuitable
	Over 65 kg to 75 kg	3	6	10
	Over 75 kg	2	4	8
Power rammer	Mass			
	100kg to 500 kg	5	8	unsuitable
	Over 500 kg	5	8	12
	Mass per square metre of base plate			

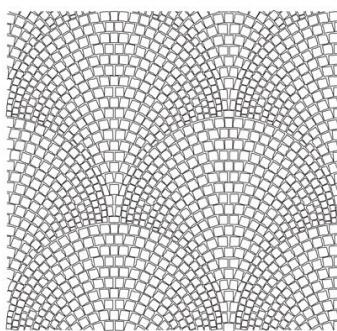
<b>Vibrating-plate compactor</b>	over 1400 kg/m <sup>2</sup> up to 1800 kg/m <sup>2</sup>	8	unsuitable	unsuitable
	over 1800 kg/m <sup>2</sup> up to 2100 kg/m <sup>2</sup>	5	8	unsuitable
	over 2100 kg/m <sup>2</sup>	3	6	10

## 29. Laying considerations

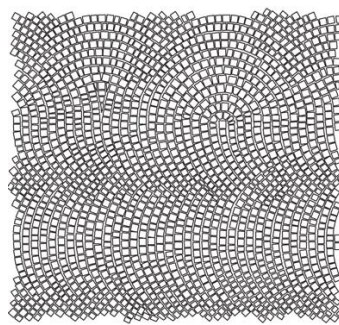
- When choosing the laying pattern for concrete pavements or sawn sided setts, it is important not to lay a stretcher course in the direction of travel into the property. This will enhance the risk of failure of the surface.
- Patterns that run across the direction of travel at a 45-degree angle are excellent for enhanced durability.
- Where possible, provision should be made to avoid laying cuts of less than half the unit size.
- When laying bound setts or blocks, cuts should be made and placed at the same time as the main run. Do not leave spaces and return to fill afterwards, as this may cause a weakness in the construction.

When using sawn sided setts and concrete block pavements, the laying patterns below will provide adequate strength for traffic categories 1 to 3.

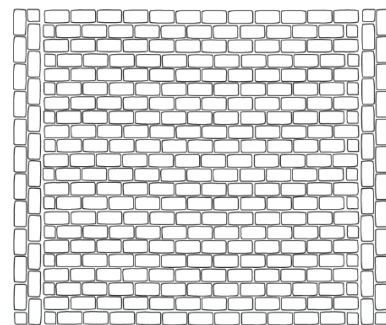
### Example laying patterns for natural stone setts



**Florentina arch  
(cubes)**

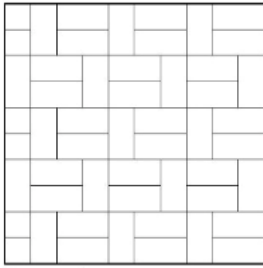


**Segmental arch  
(cubes)**

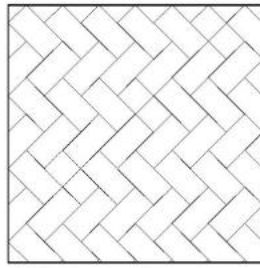


**Stretcher bond  
(cubes)**

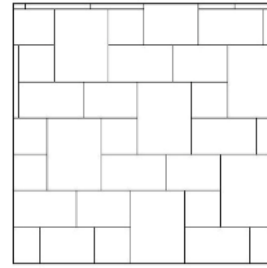
**Example laying patterns for Concrete and sawn sided setts**



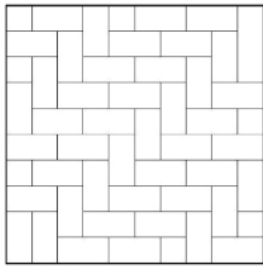
**Bespoke pattern**



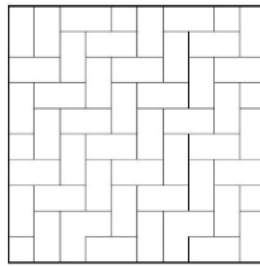
**45-degree herringbone**



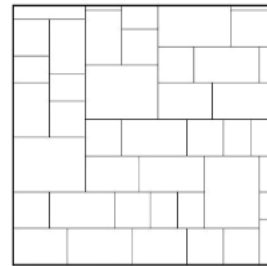
**4 mixed sizes**



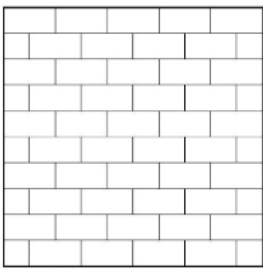
**Irregular herringbone**



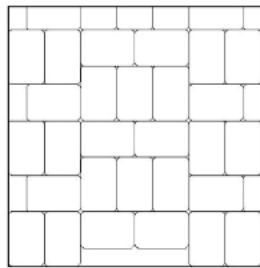
**90-degree herringbone**



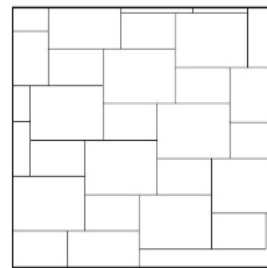
**5 mixed sizes**



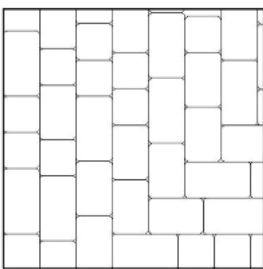
**Stretcher bond**



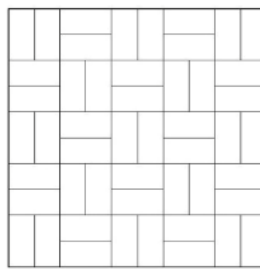
**Bespoke pattern**



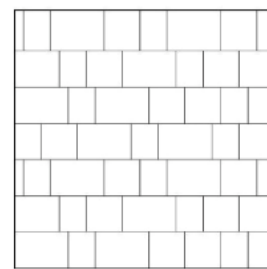
**Bespoke pattern**



**Random pattern**



**Basket weave**



**Random stretcher**

### Maximum Joint widths for unbound cropped setts

Cropped setts laid unbound should be butt jointed. The maximum width of the joint will vary as a result of the dimensional tolerances of the cropped setts as seen in the table below.

Sett width	Joint width
<70mm	0 to 8 mm
71 to 120 mm	0 to 10mm

### Minimum Joint widths for bound setts

Sett width	Dimensional tolerance class	
	Class 1	Class 2
<60mm	10mm	6mm
61 to 120 mm	12mm	8mm
>120 mm	15mm	10mm

## 30. Construction

### General unbound base construction

- Ensure all existing services have been identified.
- Ensure all appropriate subgrade suitability tests have been made and the subgrade is suitable for the proposed construction.
- All excavations should allow for the finish height of the driveway surface to be no less than 150mm below DPC of property.
- Overall excavation depths will include sub-base, bedding and surface material and will be determined by the requirements of each site.
- All materials should be non-frost susceptible and adhere to highways agency specification.
- The formation level should accurately reflect the proposed direction and elevation of the finished surface and be void of depressions or high points. Any low points in the subgrade should be filled with sub-base material, then thoroughly compacted. **Do not** fill with subgrade material.
- If using a soakaway, excavate the subgrade and install ensuring the use of suitable backfill material.
- Depending on your drainage design, the installation may be at this stage.
- Any ducting for services should be installed and their position recorded.
- Install edge restraints to the desired height on slightly compacted, semi damp, C15 concrete mix or, if using all-in ballast, a 6:1 ballast to cement ratio.
- if required ,Install intermediate restraints on C20 minimum semi damp concrete.

- Instal Non-Woven geotextile or needle punched polypropylene membrane to the subgrade and sides of the excavation. The fabric should be overlapped at a minimum of 300mm. Secure the fabric with staples or pins at intervals of approximately one square metre. Secure along the edges and at overlapping portions. A geogrid may be installed at this time to further strengthen the geotextile membrane if required.
- The sub-base material should be placed in subsequent layers of no more than 100mm depth to accurately reflect the proposed direction and elevation of the finished surface, Care should be taken to ensure that the sub-base material is well mixed to ensure even application of various particle sizes across the layer.
- Ensure that the sub-base material is not so dry as to be dusty, as this may result in poor compaction. If this is the case, a mist of water may be applied to reduce the loss of fines in the sub-base mix whilst compacting.
- The sub-base material should also not be sodden or frozen when being applied. This may also result in poor compaction.
- The sub-base material should be thoroughly compacted using a 35 kn vibrating compactor plate as a minimum.
- Passes should be alternately longitudinal and transverse in direction and each run should overlap the previous by half. One pass equates to full coverage of the site.

#### **General bound sub-base construction**

- Ensure all existing services have been identified.
- Ensure all appropriate subgrade suitability tests have been made and the subgrade is suitable for the proposed construction.
- All excavations should allow for the finish height of the driveway surface to be no less than 150mm below DPC of property.
- Overall excavation depths will include sub-base, base, bedding and surface material and will be determined by the requirements of each site.
- All materials should be non-frost susceptible and adhere to highways agency specification.
- If using a soakaway, excavate subgrade and install.
- The overall surface of the excavated sub-grade should accurately reflect the proposed direction and elevation of the finished surface and be void of depressions or high points. Any low points in the subgrade should be filled with sub-base material, then thoroughly compacted. **Do not** fill with subgrade material.
- Depending on your drainage design, the installation may be at this stage.
- Any ducting for services should be installed and their position recorded.
- Edge restraints should be installed to the desired height. on slightly compacted, semi damp, C15 concrete mix or, if using all-in ballast, a 6:1 ballast to cement ratio.
- A Geo-Textile (Non-Woven) or needle punched polypropylene membrane should be applied to the subgrade and sides of the excavation. The fabric should be overlapped at a minimum of 300mm. Secure the fabric with staples or pins at intervals of approximately one square metre. Secure along the edges and at overlapping portions. A geogrid may be installed at this time to further strengthen the geotextile membrane if required.

- The unbound sub-base material should be placed in subsequent layers of no more than 100mm depth to accurately reflect the proposed direction and elevation of the finished surface,
- Care should be taken to ensure that the sub-base material is well mixed to ensure even application of various particle sizes across the layer.
- Ensure that the sub-base material is not so dry as to be dusty, as this may result in poor compaction. If this is the case, a mist of water may be applied to reduce the loss of fines in the sub-base mix whilst compacting.
- The sub-base material should also not be sodden when being applied. This may also result in poor compaction.
- The sub-base material should be thoroughly compacted using a 35 kn vibrating compactor plate as a minimum.
- Passes should be alternately longitudinal and transverse in direction and each run should overlap the previous by half. One pass equates to full coverage of the site.
- A non-woven membrane may be placed over the unbound material at this stage. Ensure any overlaps are of at least 300mm.
- Install the chosen form of bound material ensuring that the surface is flat and parallel to the proposed overall surface layer.
- Ensure that the bound layer accurately reflects the proposed direction and elevation of the proposed finished surface and is set to a height that will accommodate the required depth of the bedding layer and surface material.
- If using Hydraulically bound material, ensure that the compaction is correctly administered.
- Provision should be made to protect the bound material whilst curing.
- If using concrete, you should ensure that, if required, the correct combination of reinforcement and/or expansion/contraction joints are applied.

## **Sub-base construction**

### General Permeable sub-base construction

For permeable driveways the base material must allow the passage of water through the sub-base toward the sub grade.

- Ensure all existing services have been identified.
- Ensure all appropriate subgrade suitability tests have been made and the subgrade is suitable for the proposed construction.
- All excavations should allow for the finish height of the driveway surface to be no less than 150mm below DPC of property.
- Overall excavation depths will include sub-base, base, bedding and surface material and will be determined by the requirements of each site. But the recommended minimum depth should be 350mm
- All materials should be non-frost susceptible and adhere to highways agency specification.
- If using a soakaway, excavate the subgrade and install.

- The overall surface of the excavated sub-grade should accurately reflect the proposed direction and elevation of the finished surface and be void of depressions or high points. Any low points in the subgrade should be filled with sub-base material, then thoroughly compacted. **Do not** fill with subgrade material.
- Depending on your drainage design, the installation may be at this stage.
- Any ducting for services should be installed and their position recorded.
- Edge restraints should be installed to the desired height on slightly compacted, semi damp, C15 concrete mix or, if using all-in ballast, a 6:1 ballast to cement ratio.
- The base of the concrete should be at least 150mm wider than the edge restraint in order to accommodate the haunch on both sides of the restraint.
- The haunch mix should match that of the concrete race and be no less than 100mm wide at the base. It should be in contact with the edge restraint to a level of at least two thirds of the height of the edge restraint and no more than 30 mm from the surface.
- The concrete overhang at the front of the restraint should be angled to fall away from it.
- geogrid may be installed at this time if required.
- install a non-permeable flexible membrane to bottom and sides of construction to form a tank. Overlapping membrane should be welded to form a watertight seal.
- Install perforated drainage pipe over the membrane to the base of the tanking and connect to drainage system. Where the drainage pipe exits the membrane, the tanking should be welded to the pipe to ensure a watertight seal.
- Add layers of clean, angular crushed stone (DTp3) in subsequent layers of no more than 100mm to a depth of 250mm (minimum) and compact between and after applications with a heavy compactor plate. (Use of a roller may not be practical) The sub-base material should be thoroughly compacted using a 35 kn vibrating compactor plate as a minimum.
- Passes should be alternately longitudinal and transverse in direction and each run should overlap the previous by half. One pass equates to full coverage of the site.
- The sub-base material should also not be sodden when being applied as this may result in poor compaction.
- A non-woven membrane should be placed over the unbound material at this stage. Ensure any overlaps are of at least 300mm.

### **Alternative permeable bound base construction**

#### **Concrete**

If a concrete base is required within a permeable design in order to add extra strength to a construction,

- 45mm plastic pipe may be inserted at 600mm centres into a minimum 150mm depth, steel reinforced concrete base.
- The pipes should extend to the unbound sub-base and be free of any bound material that may restrict the flow of water into the sub-base.

- The pipes should be level with the surface of the concrete base. Do not place pipes within 600mm of the edge of the concrete base.

### **Permeable Cementitious mortar**

**Permeable proprietary cementitious mortar may be used over an unbound sub-base to create a rigid permeable construction.**

- Place a polypropylene geogrid reinforcement mesh (Stratec G40PP or similar) over the base material to help prevent intermediate cracking between movement joints in the permeable bedding.
- Movement joints should be installed according to the geometric plan of the paved area and, the mesh should be cut at the movement joints.
- Lay 2-pack permeable bedding mortar on to the mesh.
- The minimum depth of bedding mortar should be 50mm and the minimum overall depth of paving units and bedding should be 100mm (e.g. if the paving is 40mm the bedding will need to be 60mm, if the paving is 80mm the overall depth will be 130mm).
- Priming mortar should be brush applied to the underside of the paving units during laying to ensure a good bond between the bedding and paving units.
- The paving should be jointed with permeable jointing mortar.
- Ensure that any movement joints are installed through the entire depth of the paving.
- If laying over a base of cored or permeable concrete no mesh is required.
- A 40mm bed of BS7533 Type 35 permeable bedding mortar is used with priming mortar applied to the underside of the paving units and jointed with permeable jointing mortar.
- Movement joints are installed through the entire depth of the concrete base and paving.

*Permeable paving will require regular maintenance in the spring and autumn to ensure that the joints are kept free from any material that may impede permeability.*

### **Type C non-filtration permeable driveway sub-base construction**

- Ensure all existing services have been identified.
- Ensure all appropriate subgrade suitability tests have been made and are suitable for the proposed construction.
- All excavations should allow for the finish height of the driveway surface to be no less than 150mm below DPC of property.
- Overall excavation depths will include sub-base, base, bedding and surface material and will be determined by the requirements of each site. But the recommended minimum depth should be a minimum of 350mm
- All materials should be non-frost susceptible and adhere to highways agency specification.
- If using a soakaway, excavate subgrade and install.

- The overall surface of the excavated sub-grade should accurately reflect the proposed direction and elevation of the finished surface and be void of depressions or high points. Low points in the subgrade should be filled with sub-base material, then thoroughly compacted. **Do not** fill with subgrade material.
  - Depending on your drainage design, the installation may be at this stage.
  - Any ducting for services should be installed and their position recorded. I
  - Edge restraints should be installed to the desired height on slightly compacted, semi damp, C15 concrete mix or if using all-in ballast, a 6:1 ballast to cement ratio.
  - The base of the concrete should be at least 150mm wider than the edge restraint in order to accommodate the haunch on both sides of the restraint.
  - The haunch mix should match that of the concrete race and be no less than 100mm wide at the base. It should be in contact with the edge restraint to a level of at least two thirds of the height of the edge restraint and no more than 30 mm from the surface.
  - The concrete overhang at the front of the restraint should be angled to fall away from it.
  - geogrid may be installed at this time if required.
  - install a non-permeable flexible membrane to bottom and sides of construction to form a tank. Overlapping membrane should be welded to form a watertight seal.
  - Install perforated drainage pipe over the membrane to the base of the tanking and connect to drainage system. Where the drainage pipe exits the membrane, the tanking should be welded to the pipe to ensure a watertight seal.
  - Add layers of clean, angular crushed stone (DTp3) in subsequent layers of no more than 100mm to a minimum depth of 250mm and compact between and after applications with a heavy compactor plate. (Use of a roller may not be practical) The sub-base material should be thoroughly compacted using a 35 kn vibrating compactor plate as a minimum.
  - Passes should be alternately longitudinal and transverse in direction and each run should overlap the previous by half. One pass equates to full coverage of the site.
  - The sub-base material should also not be sodden when being applied as this may result in poor compaction.
  - A non-woven membrane should be placed over the unbound material at this stage to stop migration of bedding layer. Ensure any overlaps are of at least 300mm.
- *Further information about SuDS drainage systems can be located at The National Suds Standards*  
*[www.susdrain.org](http://www.susdrain.org)*

## **1. Driveway Construction from bedding layer to finish**

### **block paving with surface drainage**

- Install suitable foundation (see sub-base and bases section) to allow for the overall proposed construction to finish no less than 150mm from damp proof of house.
- If using Sawn-sided setts in an unbound driveway construction, it is advised that sandstone should be used in order to create adequate frictional interlock between the setts and the jointing material.
- Fill area with coarse grit sand to a minimum depth of 40mm. (extra depth of material will be required to allow for screeding)
- The height of the sand should allow for the depth of block to finished height of surface plus approximately 5mm to allow for settlement during compaction. (Depth allowance varies depending on size of compactor plate, moisture content of sand etc.)
- Compact sand using a suitable heavy plate compactor.
- Screed to desired levels. Any troughs left in bedding layer upon removal of screed rails should be filled with coarse grit bedding material and compacted with a float to match finished screed level.
- Lay paving material in chosen pattern. Always mix packs to ensure even colouration.
- Cuts should be made using a diamond cut off saw. Do not place small cuts to the edges of the driveway as this may cause a weakness in the overall construction and look untidy. if possible, ensure cuts are never less than one third of the block length.
- Ensure that any cuts to recessed manhole covers are aligned with the pattern of the driveway and where a block spans the driveway and manhole, ensure that the same block is used to maintain colour consistency.
- If laying chamfered concrete blocks, compact the blocks before applying the silica sand. If using clay pavers, blocks without a chamfer or with a small chamfer, apply dry silica sand and brush into joints. (this should be carried out when block paving is dry). Ensure the gaps are completely filled.
- Run a heavy plate compactor over the blocks a minimum of three times in each direction.
- A rubber or neoprene sole plate should be used with the compactor to avoid impact damage to the surface of the units.
- Add more sand if required.
- Sweep silica sand into any remaining gaps and remove the excess surface sand.

### **Setts and cobbles (Reclaimed) non-permeable.**

- Install suitable foundation (see sub-base and bases section) to allow for the overall proposed construction to finish no less than 150mm from damp proof of house.
- Ensure the cobbles/setts are clean before applying a proprietary primer immediately before laying setts/cobbles, ensure the primer does not dry out before laying.

- Lay setts/cobbles on a semi damp bedding layer of 4:1 ratio washed sharp sand and cement mortar or proprietary bedding mortar to a minimum depth of 100mm. The mortar should be compressed slightly before bedding the stone into it with a rubber mallet.
- The bedding depth may vary due to varying stone depths, therefore pick the deepest stone and adjust bedding depths as required.
- Ensure the consistency of the joint widths and bring to a minimum of 8 and a maximum of 12mm if possible.
- joint with 3:1 ratio sharp sand /cement mortar, suitable non-porous proprietary jointing material or proprietary cement-based mortar.
- Any excess mortar should be cleaned from the surface immediately.

### **Setts and cobbles (Reclaimed) permeable.**

- Install suitable permeable foundation (see sub-base and bases section) to allow for the overall proposed construction to finish no less than 150mm from damp proof of house.
- Ensure the cobbles/setts are clean before applying a proprietary primer immediately before laying setts/cobbles, ensure the primer does not dry out before laying.
- Lay setts/cobbles on a proprietary permeable bedding mortar to a minimum depth of 100mm.
- The bedding depth may vary due to varying stone depths, therefore pick the deepest stone and adjust bedding depths as required.
- Ensure the consistency of the joint widths and bring to a minimum of 8 and a maximum of 12mm if possible.
- joint with permeable proprietary jointing mortar
- Any excess mortar should be cleaned from the surface immediately

### **block paving Permeable**

- Install suitable permeable foundation (see sub-base and bases section) to allow for the overall proposed construction to finish no less than 150mm from damp proof of house.
- Place a second layer of non-woven membrane over the sub-base layer to prevent
- Fill area with 2-6mm coarse aggregate to a minimum depth of 50mm (extra depth of material will be required to allow for screeding)
- The height of the coarse aggregate should allow for the depth of block to finished height of surface plus approximately 2 to 3 mm to allow for settlement during compaction.
- (Depth allowance varies depending on size of compactor plate but it is generally less than with grit sand laying courses.)
- Screed to level.

- Ensure that blocks used are **permeable** block paving system blocks.
- Lay blocks in specified pattern. Always mix packs to ensure even colouration.
- Cuts should be made using a diamond cut off saw.
- Compact blocks with a plate compactor.
- A rubber or neoprene sole plate should be used with the compactor plate to avoid impact damage to the surface of the units.
- Apply 2-6mm grit and brush into joints
- Remove excess grit.

### **Gravel semi-permeable**

- Install suitable foundation (see sub-base and bases section) to allow for the overall proposed construction to finish no less than 150mm from damp proof of house.
- Excavation depth may be reduced to 150mm on load bearing, free draining subgrade.
- Apply chosen gravel to surface. Do not over apply gravel as this will cause a “beaching” effect, generally, apply surface material at a depth of 1.5 to 2 times its own size.

### **Gravel permeable**

- Install suitable permeable foundation (see sub-base and bases section) to allow for the overall proposed construction to finish no less than 150mm from damp proof of house.
- Place a second layer of non-woven membrane over sub-base layer to prevent laying course particles migrating into larger base material (optional)
- Install a layer of 7 to 10mm of angular aggregate to a depth of approximately 5 to 10mm and screed.
- The finished screed height should allow for the proposed finished height of the stabilising grids and surface gravel.
- Place stabilizing grid over aggregate ensuring adherence to manufacturers specification.
- Infill stabilizing grid with angular gravel aggregate. Of chosen type and size.

### **Resin bound permeable**

- Install suitable permeable foundation (see sub-base and bases section)
- Lay an 80mm depth of open graded AC14 porous surface macadam (max 100/150 pen) to required levels allowing for 18mm surface course of resin bound material
- Ensure the asphalt layer is adequately compacted (a minimum of a 35kn compactor plate)
- Lay resin bound product (typical depth of 18mm) and hand trowel to finish.

(follow manufacturers recommendations for mixing and application)

- A glass grit may be applied to the surface whilst still tacky to add slip resistance.
- Eco grid may be used as a base for smaller applications.
- A concrete base may be used with resin-bound material, but it will not comply with SUDS regulations unless the concrete is porous, or a drainage system is installed.
- Resin-bound and bonded aggregates have specific requirements regarding laying conditions and application. It is recommended that you always consult the manufacturer for further guidance before considering laying.
- Variations in temperature and humidity can greatly affect the application process and speed of curing. If there is a possibility of rain, the products should not be laid. If there is a possibility of rain with 24 hours of the systems application, it would be advisable to protect the resin by covering it up to prevent water reacting with the uncured resin.

*Resin-bound and bonded aggregates have specific requirements regarding laying conditions and application. It is recommended that you always consult the manufacturer for further guidance before considering laying.*

### **Resin Bonded with non-permeable concrete base**

- Install suitable foundation (see sub-base and bases section) to allow for the overall proposed construction to finish no less than 150mm from damp proof of house. Any expansion or contraction joints in the base must extend to the surface.
- A resin bonded material must be laid on a monolithic surface. When laying a new base for the Resin Bonded system, make sure it has been allowed to cure properly prior to the application of the resin system. (Recommended 28 days)
- If laying a Resin Bonded surface onto concrete, a suitable epoxy primer and c52 sand will be required to aid bonding.
- The resin and hardener should be mixed with a drill paddle mixer for several minutes to ensure everything is combined,
- if an accelerator is required in colder temperatures (below 15 degrees) and if there is a chance of dew or light rain overnight it should be added at this stage
- In warm temperatures setting times could be 2 to 4 hours but in autumn and winter resin can still be tacky the next morning,
- Apply resin bonded material to 3mm depth (approx.)
- Mask off any edges that need to be protected with masking tape prior to pouring the resin.
- The resin mixture is then poured in a series of lines and spread evenly over the prepared surface using a serrated squeegee.
- Leave for around 10 minutes to allow the resin to self-level.
- broadcast the aggregate onto the surface ensuring that the resin is completely covered.

- Resin-bound and bonded aggregates have specific requirements regarding laying conditions and application. It is recommended that you always consult the manufacturer for further guidance before considering laying.
- Avoid walking on the aggregate or resin whilst broadcasting. Once the aggregate has been broadcast, any masking tape should be removed.
- Keep an eye out for any resin rich areas and ensure sufficient aggregate is applied to them to keep the surface appearance consistent.
- If adjoining areas are to be treated, leave a wet edge (sometimes referred to as a hot line) and start the application for this area as the previously laid area is setting
- Keep the run going until the full area is completed.
- If large areas are to be covered careful planning is required to ensure a suitable finishing or day joint can be formed. A suitable point might be a drainage grid line or kerb.
- Variations in temperature and humidity can greatly affect the application process and speed of curing. If there is a possibility of rain, the products should not be laid. If there is a possibility of rain with 24 hours of the systems application, it would be advisable to protect the resin by covering it up to prevent water reacting with the uncured resin.

*Resin-bound and bonded aggregates have specific requirements regarding laying conditions and application. It is recommended that you always consult the manufacturer for further guidance before considering laying.*

### **Resin Bonded with non-permeable macadam base**

- A resin bonded material should be laid on a monolithic surface. When laying a new base for the Resin Bonded system, ensure it has been allowed to cure completely prior to the application of resin system. (28 days recommended)
- Install suitable foundation (see sub-base and bases section) to allow for the overall proposed construction to finish no less than 150mm from damp proof of house.
- Lay a 70 to 100mm depth of close graded asphalt to reflect the proposed finished surface levels and compact with a double drum vibrating roller or 35kn compactor plate as a minimum if space is tight.
- The resin and hardener should be mixed with a drill paddle mixer for several minutes to ensure everything is combined,
- if an accelerator is required in colder temperatures (below 15 degrees) and if there is a chance of dew or light rain overnight it should be added at this stage
- In warm temperatures setting times could be 2 to 4 hours but in autumn and winter resin can still be tacky the next morning,
- Apply resin bonded material to 3mm depth (approx.)
- Mask off any edges that need to be protected with masking tape prior to pouring the resin.

- The resin mixture is then poured in a series of lines and spread evenly over the prepared surface using a serrated squeegee.
- Leave for around 10 minutes to allow the resin to self-level.
- broadcast the aggregate onto the surface ensuring that the resin is completely covered.
- Avoid walking on the aggregate or resin whilst broadcasting. Once the aggregate has been broadcast, any masking tape should be removed.
- keep an eye out for any resin rich areas and ensure sufficient aggregate is applied to them to keep the surface appearance consistent.
- If adjoining areas are to be treated, leave a wet edge (sometimes referred to as a hot line) and start the application for this area as the previously laid area is setting
- keep the run going until the full area is completed.
- If large areas are to be covered careful planning is required to ensure a suitable finishing or day joint can be formed. A suitable point might be a drainage grid line or kerb.
- Variations in temperature and humidity can greatly affect the application process and speed of curing. If there is a possibility of rain, the products should not be laid. If there is a possibility of rain within 24 hours of the systems application, it would be advisable to protect the resin by covering it up to prevent water reacting with the uncured resin.

*Resin-bound and bonded aggregates have specific requirements regarding laying conditions and application. It is recommended that you always consult the manufacturer for further guidance before considering laying.*

*Both asphalt and macadam are used for surface pavements, roads, and driveways, but they are different material. Tarmac is a blend of tar and aggregates, whereas asphalt is a blend of bitumen and aggregates. Tarmac is easy and quick to install and a little bit cheaper than asphalt. However, asphalt is more eco-friendly than tarmac as you can break and reuse it at the end of the useful life expectancy. Asphalt tends to have better tire grip and has a longer life expectancy in general.*

### **Macadam permeable**

- Install suitable permeable foundation (see sub-base and bases section) to allow for the overall proposed construction to finish no less than 150mm from damp proof of house.
- Lay a 50 to 100mm mm depth of AC20 open graded permeable macadam binder course and compact with a double drum vibrating roller or 35kn compactor plate as a minimum if space is tight.

- Lay a 35mm depth (minimum) of permeable macadam surface course and compact with a double drum vibrating roller or 35kn compactor plate as a minimum if space is tight.

*Macadam and asphalt surfaces have specific requirements regarding laying conditions and application. It is recommended that you always consult the manufacturer for further guidance before considering laying.*

### **Macadam non-permeable**

- Install suitable foundation (see sub-base and bases section) to allow for the overall proposed construction to finish no less than 150mm from damp proof of house.
- Lay a 70 to 100mm layer of 20mm macadam binder course and roll with a double drum vibrating roller or 35k compactor plate as a minimum if space is tight.
- Lay 25 to 40mm of 6mm macadam wearing course and compact with a double drum vibrating roller or 35kn compactor plate as a minimum if space is tight.

*Macadam and asphalt surfaces have specific requirements regarding laying conditions and application. It is recommended that you always consult the manufacturer for further guidance before considering laying.*

### **Porous concrete**

*Porous concrete is not a very commonly used driveway material and it has specific requirements regarding laying conditions and application. It is recommended that you always consult the manufacturer for further design and application guidance before considering laying.*

## **31. Health and Safety**

### **Cutting.**

- Cutting of stone should be done by using a diamond tipped power saw or bench saw, a block-splitter or hammer and bolster. Specific equipment or blade types should be used when cutting natural stone units as those designed for cutting concrete pavers may blunt easily.
- For porcelain it is advisable to use a water cooled, diamond bladed bench power saw.
- The cutting blade should be water suppressed whenever cutting any paving to control dust and cool the blade.

- Stone cutting should only be carried out by operators with the correct experience, or whilst training under supervision.
- For more information, please refer to:  
*<https://www.hse.gov.uk/construction/healthrisks/hazardous-substances/cutting-paving-blocks-kerbs-and-flags.htm>*

**PPE.**

- The minimum PPE requirements for cutting stone are;
- Steel toe cap Boots, gloves, eye protection, ear defenders and face mask. This should always be adhered to.