GUIDELINES FOR SUCCESSFUL FUNCTIONAL AND STRUCTURAL PERFORMANCE OF BOSUN WATERWISE PAVERS

Please Note:
This document is merely guidelines for the installation of the Bosun Waterwise paver. Individual analysis and design of a specific site would have to be conducted by a qualified engineer.
Bosun could be contacted in order to provide the services of a contracted industry expert in this field in order to assist engineers for a nominal fee.

The Bosun Waterwise paver brings a new dimension to aesthetic appeal and drainage capability of large areas used by pedestrian or vehicular traffic. Successful use is however dependent on proper design and installation. These guidelines assist practitioners in specifying and applying sound procedures. They are focused on specific requirements and are supplemental to general industry documents such as the Concrete Manufacturers Association (CMA) “An introduction to permeable concrete blocks”.

MANAGING WATER RUNOFF

Managing water runoff is a current environmental focus, as it manages surface water by attenuation and filtration with the aim of replicating, as closely as possible, the natural drainage from a site before development.

Managing water runoff consists of:
- minimize water runoff QUANTITY;
- improve water QUALITY; and
- provide AMENITY and biodiversity through an improvement of the environment.

There are three permeable concrete block pavement (PCBP) systems, which are commonly known as Systems A, B and C. The systems possess different drainage attributes, but visually look the same.

System A – full infiltration

This system is suitable for existing soil (subgrade) conditions with good permeability, and allows all the water falling onto the surface to infiltrate through the constructed layers to the water table, as shown in Figure 1. No water is discharged into conventional drainage systems, eliminating the need for pipes. This system is only suitable if the subgrade can accept the water without complications.

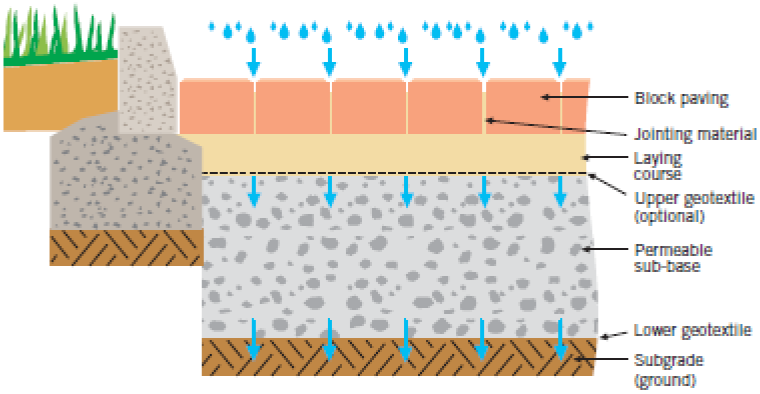

Figure 1. System A – full infiltration.

System B – partial infiltration

This system is used where the existing soil (subgrade) is unable to absorb all the water that falls on the surface. Surplus water is then removed by a pipe drainage system in the pavement structure, as shown in Figure 2. By the attenuation achieved in the permeable subbase, runoff, and thus the danger of flooding, is significantly reduced.

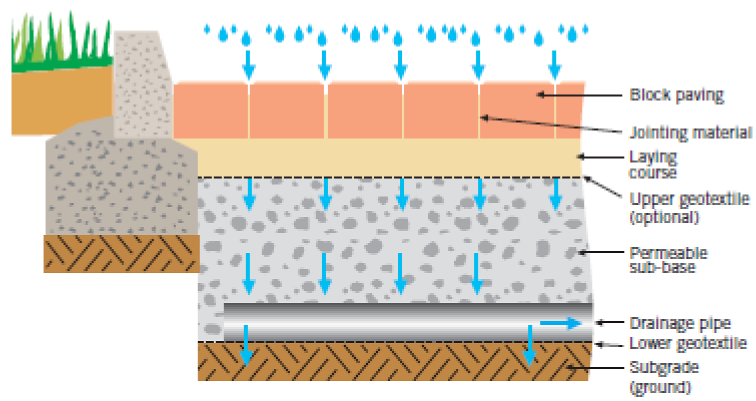

Figure 2. System B – partial infiltration.

System C – No infiltration

Where the existing soil (subgrade) is poor or contains pollutants, System C allows for the complete capture of all the rainfall, as shown in Figure 3. The porous nature of the subbase functions as a storage tank, reducing peak flows through the outlet pipes leading to other surface drainage systems such as ponds or water courses.

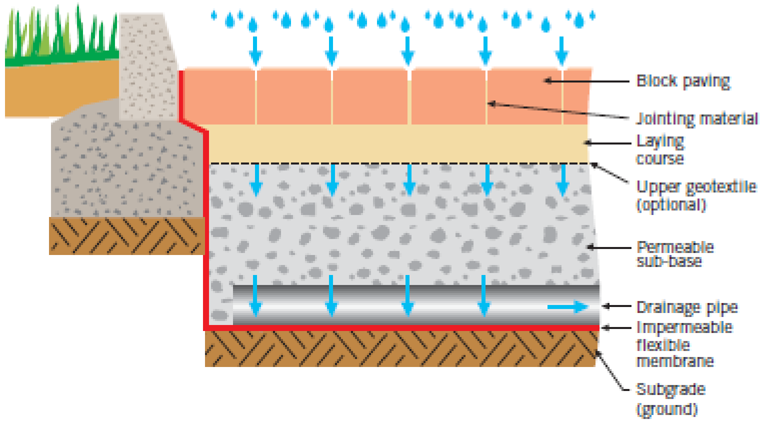

Figure 3. System C – no infiltration

DESIGN REQUIREMENTS

Lower membrane

In Systems A and B the lower membrane should be a permeable geotextile, to allow water infiltration. This membrane should have the required strength not to be damaged when the stone for the subbase is placed, and it should remain permeable (not clogged) during the life of the facility. In System C the lower membrane is impermeable, being capable of being welded to ensure a complete seal, and strong enough not to be damaged (holes punched) when the porous subbase is constructed.

Subbase thickness requirements

The permeable subbase consists of a 26.5 mm or 19 mm single sized crushed stone. This type of stone has about 40% of the volume as air voids, which means that 40% of the layer volume can be filled with water. If the layer is 150 mm thick, it can accommodate 60 mm of rainfall in the layer if there is no infiltration or outflow. This is sufficient for most rainfall events. In cases where more substantial requirements must be provided, advanced analysis techniques are available, and BOSUN is able to provide a service to assist designers. (We utilize the services of an academic in this field. The costs and timeframes of consultation would be determined by this individual.)

From a structural perspective, a 150 mm permeable subbase is sufficient to carry 1 million standard 80 kN axles during the life of the facility (about 25 trucks per day) on a subgrade with a CBR of at least 15. This is adequate for most applications in the urban environment, such as access streets, parking areas, hardstands around office and residential properties.

For large projects or facilities carrying large numbers of heavy vehicles where the implications of inadequate structural design are significant, detailed mechanistic design can be performed by specialist pavement engineers. BOSUN offers a service to assist with the structural design or review designs as mentioned above.

Construction of permeable subbase and bedding layer(s)

On Figures 1 to 3 a permeable geotextile membrane is shown as separator between the coarse stone and the bedding layer. From a functional perspective a membrane is a feasible solution, but in practice this invariably causes problems. Before the membrane is placed, particle interlock of the coarse aggregate must be achieved by using a heavy roller with a mass of at least 8 ton and preferably with vibrating capability. A 1-ton walk behind roller does not achieve particle interlock. The area to be paved has to be completed so that the membrane can be placed (this is sometimes difficult to achieve on a small site). After construction of the paving, if trenching has to be done the membrane is invariably pulled up and not reinstated after trenching is complete.

An alternative to using a geotextile membrane, yet preventing the bedding sand from disappearing into the coarse stone layer, would be to select progressively finer materials. These materials are selected using the well-known filter criteria, as is explained next.

The two aggregate materials should meet the following criteria:

$$\frac{D_{15}\ \text{subbase}}{D_{85}\ \text{bedding layer}}$$

must be less than or equal to 5.

where Dx is the particle size at which x% are finer. Using the example in Figure 4, D_{15} subbase is the size where 15% of the subbase is finer, namely 8 mm, and D_{85} bedding layer is the size where 85% is finer, namely 3.7 mm.

The ratio of 8/3.7 is 2.16, which is less than 5 and thus satisfactory.

It is advisable to check visually on site that the laying course particles fit into the voids of the sub-base material without excessive migration into the sub-base.

The bedding layer should have a thickness of 20 mm to ensure that undue deformation does not take place, but adequate drainage occurs. The bedding layer is spread after complete compaction of the subbase with a heavy roller to achieve full particle interlock. Compaction of the bedding layer is by means of a plate vibrator on the paving blocks.

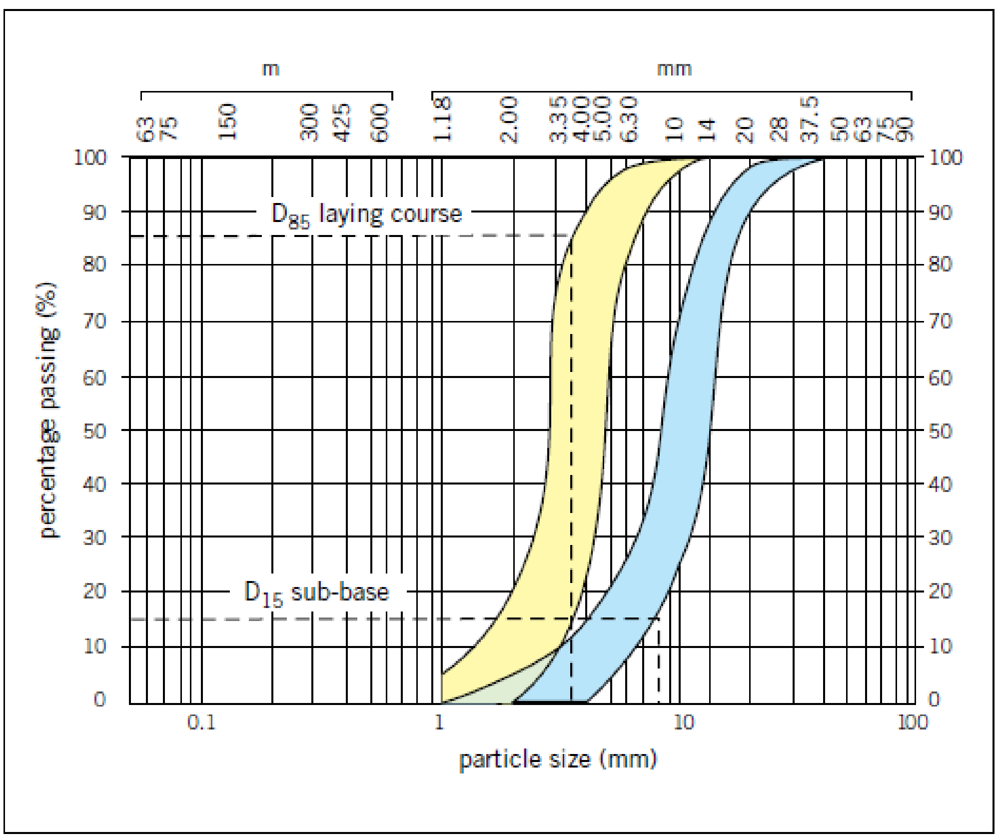

Figure 4. Example grading characteristics of permeable subbase (blue) and bedding layer (yellow).

Jointing material

The role of the jointing material is to ensure drainage through the joints in the paving blocks, and to achieve "lock-up" in the paving system. "Lock-up" is when the paving blocks function as a unity and not individual blocks, and provide structural strength. By vibrating the dry jointing material into the joints load transfer between blocks is achieved.

The joints in WATERWISE permeable pavers are 3 to 5 mm in width. The maximum size jointing material can thus be no larger than 2 mm, as a rule of thumb suggests the maximum size to be two-thirds of the joint spacing. The jointing material should have no fine material passing the 0.425 mm sieve. In the large squares of the WATERWISE permeable paver a 6.7 mm single size stone can initially be placed to improve permeability before the jointing sand is added. The suggested materials fulfill the filter criteria and will not wash into the subbase.

Should the WATERWISE paver be used for aesthetic purposes and not for its drainage capability in a standard pavement, conventional jointing sand should be used to try and make the system impermeable.