National Highways Sector Scheme 30

for Modular Paving

Concrete or clay pavers, concrete or stone flags or sawn stone setts, laid on an aggregate laying course

Technical Training Manual - Course Framework

national highway sector schemes

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Introduction

This manual addresses the procedures for installing a pavement with a wearing surface comprising either concrete or clay pavers, concrete or stone flags, or sawn stone setts. All of these paving units are laid on an aggregate laying course. This type of surfacing is often referred to as flexible modular paving and, when installed on an appropriately designed and constructed base, is suitable for a wide range of applications for pedestrian and trafficable pavements.
This manual is to be used as a basic aid for developing training material and presentations for the delivery of training for these paving types. (An accompanying manual - *Training Resources Manual* - gives additional training resource material, such as images and diagrams).

A separate manual *Rigid pavement construction using pre-cast concrete pavers and flags, clay pavers and natural stone slabs and setts laid without applied vibratory compaction* is to be used as a basic aid for developing training material and presentations for the delivery of training for this type of installation.

This manual does not cover the construction of the pavement base below the surfacing.

The installation procedures and properties of materials are based upon the requirements set out in the appropriate British Standards.

Health & Safety

All work should be undertaken in compliance with current health and safety legislation. Information and guidance addressing safety issues associated with this industry sector, such as handling and cutting, can be downloaded (free of charge) from the Interpave website: www.paving.org.uk

Definitions

The following definitions are generally taken from British Standards.

Note: for the purpose of this manual, reference is made to one or more of the following paving types, but where the term 'flag' has been used in this manual, this means either a concrete flag or a natural stone slab.

Paving unit - all types of blocks, clay pavers, flags or setts, regardless of the material, but suitable for use as a modular paving surface.

Blocks or block paving - manufactured from concrete.

Clay paving - manufactured from clay.

Flag - a precast concrete unit, used as a paving material, with an overall length that does not exceed 1.5m and which when divided by its thickness is greater than four.

Slab - a unit of natural stone used as a paving material in which the working width exceeds 150mm and also generally exceeds twice the thickness.

Natural Stone sett or sawn sett – a natural stone paving unit with work dimensions between 50mm and 300mm, and no plan dimension generally exceeding twice the thickness. The nominal thickness for unbound construction is equal to or greater than the width.

Restraint – a device that serves to prevent lateral movement of paving units and loss of the laying course.

Geotextile - a permeable textile, mesh, net or grid that allows water to flow though and prevents migration of particles between construction layers.

Intermediate restraint – a restraint used at intervals along an area being paved.
Note: intermediate restraints are generally used when steeply sloped areas are being paved.

Temporary restraint – a restraint used when a partially paved area is to be trafficked or when it is necessary to preserve the integrity of the laying face at the end of the working period.

Interlock – the effect of frictional forces between paving units which prevents them from moving.

Laying course – a layer of aggregate on which paving units are bedded (sometimes referred to as a bedding layer or bedding sand).

Laying face – the working edge of the surface course, against which paving units are placed.

Roadbase - one or more layers of material placed above the sub-base that constitute a structural element of a flexible or composite pavement, such as cement stabilised (hydraulically bound) material or dense bitumen macadam (DBM).

Sub-base - one or more layers of material placed immediately above the subgrade.

Subgrade - part of the soil, natural or constructed that supports the loads transmitted by the overlying pavement.

Capping layer – a layer of granular or stabilized material at the top of the subgrade to provide a working surface and an improved foundation for the pavement.

Surface course – a layer of interlocked paving units that acts as a wearing surface and forms part of the structure of the pavement.

Inboard cut – a paving unit that is cut to one quarter or more of its original length.

Laying pattern – an arrangement of paving units intended either for structural requirements or for visual effects.

Jointing material - aggregate applied to fill the joints between paving units.

Joint width (or paving gap or joint space) – the distance between adjacent paving units or between units and restraints**.**

Lipping – the relative height between adjacent blocks.

Standards

British European Standards relevant to manufacturing and testing of paving units are tabulated in Table 1.

Table 1 - Relevant manufacturing and testing standards

British European Standard Number	Title
BS EN 1338:2003	**Concrete paving blocks. Requirements and test methods.**
BS EN 1344:2003	**Clay pavers. Requirements and test methods.**
BS EN 1338:2003	**Concrete paving flags. Requirements and test methods.**
BS EN 1341:2001	**Slabs of natural stone for external paving. Requirements and test methods.**
BS EN 1342:2001	**Setts of natural stone for external paving. Requirements and test methods.**

These standards deal with manufacturing and testing issues. The most important criteria for the paving installer are the dimensional tolerances because if the paving units are out of tolerance it may be difficult to achieve compliant joint spacing and surface smoothness.

British Standards relevant to installation are tabulated in Table 2.

Table 2 - Relevant Installation Standards

British Standard Number	Title
BS 7533-3: 2005 +A1: 2009 Note: an amendment was made in 2009 to the requirements of laying courses for heavy duty applications, hence 2005 + A1	**Pavements constructed with clay, natural stone or concrete pavers.** Part 3: Code of practice for laying precast concrete paving blocks and clay pavers for flexible pavements.
BS 7533-4: 2006	**Pavements constructed with clay, natural stone or concrete pavers.** Part 4: Code of practice for the construction of pavements of precast concrete flags or natural stone slabs.
BS 7533-7: 2010	**Pavements constructed with clay, natural stone or concrete pavers.** Part 7: Code of practice for the construction of pavements of natural stone sett paving units and cobbles, and rigid construction with concrete block paving.

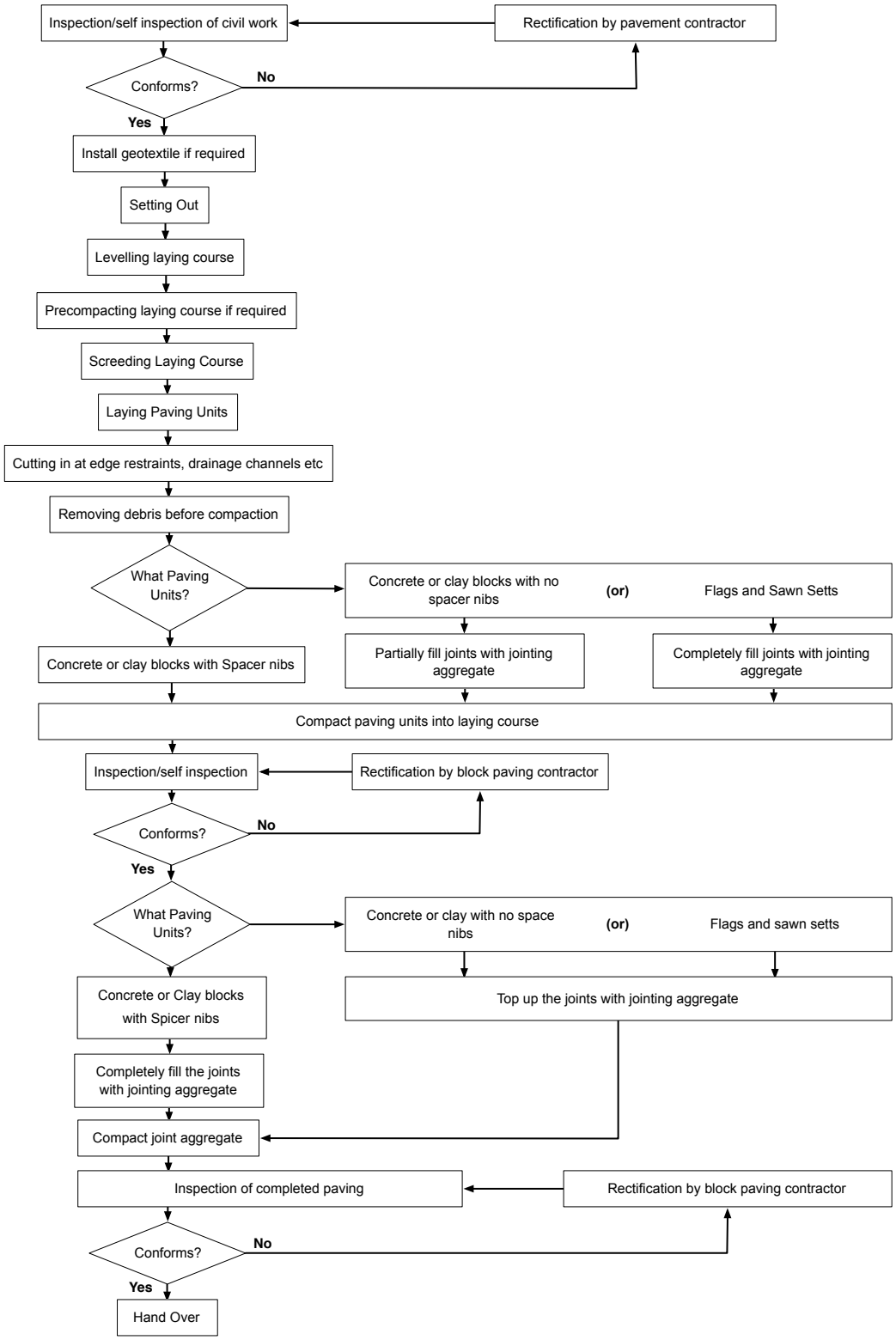
The key requirements of these standards are:

- Material specifications (laying and jointing)
- Installation procedure
- Edge restraints
- Laying course thickness – moisture content, pre-compaction
- Laying pattern
- Joint spaces
- Compaction equipment
- Lipping
- Surface level and smoothness
- Cutting/edge details
- Compaction equipment
- Tolerances

Installation Procedure

Installation of precast concrete paving blocks, clay pavers, flags (slabs) and sawn setts should follow the procedures shown in the following flow chart. This flow chart is based upon the information from the relevant British Standards.

Annex A (normative) Procedure for constructing a pavement
A flow chart of the general sequence of operations involved in constructing a pavement is represented as a flow chart in Figure A.1. The flow chart reflects the content of clause 5.



Inspection and Self-inspection of Civil Works

Generally, civil works are undertaken by a different contractor but, regardless of who is responsible for this work, prior to commencing paving installation the preceding work should be inspected by a competent person to confirm compliance with the contract specification and drawings to that stage. Only if the preceding work is compliant should the paving installation work be allowed to proceed. Any non-compliance must be corrected and re-inspected before proceeding with the paving installation.

Typically, items that may need inspection are:

- Levels of the road or sub-base are correct and relate to adjoining pavements and structures, allowing for the correct depth of laying course aggregate. Road and sub-base tolerances are given in Table 3.

Table 3 - Road and sub-base tolerances

	Conventional paving (non-permeable paving, concrete or clay)	Permeable Paving	Flags, stone or concrete	Sawn setts
Road base level tolerance	+ 5mm - 10mm	na	+ 5mm - 10mm	+ 0mm - 12mm
Sub-base level tolerance	+ 5mm - 10mm	± 20mm	+ 5mm - 10mm	+20mm -15mm

- Gradients, changes in gradients and surface smoothness: the transitions at changes of gradients should be smooth and such that they do not cause rapid changes in surface smoothness that may result in opening up of joints or direct contact of paving units.

- Drainage points, manholes, flush kerbs, etc., are set at the correct line, level and gradient, and such that, after paving unit installation, the surface of the paving is 5mm above these points allowing for the correct depth of laying course aggregate.

- The base levels are such that, after the paving units are installed, the surface levels will be at least 150mm below damp course levels.

- The base levels are such that, after the paving units are installed, the surface levels of the paving are compliant in relation to edge restraints, flush kerbs, containment kerbs, etc.

- That positive drainage can be achieved to ensure that no ponding of surface water occurs (this does not apply to permeable pavements).

- Intermediate edge restraints are utilised.

Geotextiles

Some pavements, particularly permeable pavements, may require the installation of an upper geotextile to prevent the migration of laying course into the lower pavement layer. If so, it should meet the specifications shown in Table 4 and the following requirements:

- The geotextile can be either a mono filament woven, non-woven bonded or needle punched non-woven fabric.
- The geotextile shall be manufactured from a suitable polyethylene or polypropylene filament able to withstand naturally occurring chemical and microbial effects.
- The tensile properties of the material shall be verified in accordance with BS EN ISO 10319: 1996 by both internal quality assurance and external quality control, and assurance by an independent authorised laboratory.
- The production of the geotextile shall be in accordance with BS EN ISO 9001: 2008 and each roll shall have at least one identification label. This should cover the roll number and product type in accordance with BS EN ISO 10320: 1999 and carry a relevant CE mark.
- The geotextile shall be protected from ultraviolet light whilst stored.
- The geotextile shall be installed with 300mm overlaps between each piece.
- It will be necessary to cut the geotextile to fit around penetrations such as bollards or drainage points and install it such that the geotextile is turned up at 90º to the full height of the paving unit.

Table 4 - Geotextile specification

Characteristics	Standard	Woven Filter	Non-woven Filter
Weight	BS EN 965: 1995	≥ 200 g/m^2	≥ 300 g/m^2
Ultimate Tensile Strength: Longitudinal Transverse	BS EN ISO 10319: 1996	 ≥30 kN/m ≥30 kN/m	 ≥15 kN/m ≥15 kN/m
Strain at Nominal Tensile Strength: Longitudinal Transverse	BS EN ISO 10319: 1996	 ≤ 25% ≤ 25%	 ≤ 70% ≤ 70%
CBR Puncture	BS EN ISO 12236: 2006	≥3 kN	≥3 kN
Opening Size	BS EN ISO 12956: 1999	≥0.2 mm	≥0.1 mm
Water Permeability	BS EN ISO 11058: 1999	≥ 20 x 10^{-3} m/s	≥ 40 x 10^{-3} m/s

Setting Out

- Consideration must be given to the laying pattern and its orientation, and setting out of datums to assist in achieving straight lines, curves etc., as designed.
- To assist in maintaining alignment for dimensionally large projects, such as large car parks, container yards or municipal malls, it maybe desirable to set out a grid with flush nails, typically on a 10m x 10m grid.
- Paving materials must be located in the appropriate places to minimise trafficking and turning of construction vehicles on the prepared base.
- If working in a public area, e.g. refurbishment work to a public highway, then work and safeguarding workers and the public must be in compliance with the *New Street Works Act*.
- If working in a non public area, then working and safeguarding workers must be in compliance with the lead contractor's/ client's requirements.

Levelling the Laying Course

- The laying course aggregate (sometimes called bedding sand in conventional pavements) needs to be spread out to a thickness to allow screeding without a large surplus having to be displaced during the screeding process.
- The laying course should contain no binding material, such as cement, which will act as a binder that could detract from the flexible nature of the pavement.
- For conventional block pavements (non-permeable pavements) the British Standard categorises the laying course for particular applications: see the Laying Course Categories Applications, Table 5.
- For conventional block, flag and sett pavements (non-permeable pavements) the laying course should be naturally occurring sand from the quaternary geological series or sea-dredged sands. It should comply with the appropriate grading requirements and, in the case of concrete block and clay paver pavements, these grading requirements depend upon the traffic application.
- For concrete block and clay paver pavements, recycled aggregate (sand) may be used as laying course for categories of pavement applications II, III and IV. It should comply with the grading requirements, depending upon the application.
- For conventional non-permeable pavements, if there is a danger of a significant head of water developing or any water is trapped within the laying course, then consideration needs to be given to draining this water. (This should have been dealt with in the design process).
- For conventional block, flag and sett pavements (non-permeable pavements), the laying course should be moist without being saturated, with no free water, and should bind together when squeezed in a gloved hand and the pressure released.
- With conventional block, flag and sett pavements (non-permeable pavements), if the prepared laying course becomes saturated prior to laying the blocks, it can be removed and replaced with fresh sand or allowed to dry out.
- It is good practice to keep the stockpile of laying course aggregate covered up to avoid issues with saturation and potential contamination from other construction materials.
- Permeable laying course aggregate: as this material is free draining, the moisture content has no appreciable effect during construction but it is still good practice to keep the stockpile covered up to avoid potential contamination from other construction materials that may adversely affect the permeability.

Laying Course Aggregates

Conventional pavements (non-permeable): concrete block and clay paver

Block pavement laying course aggregate (sand) is categorised depending on the application, as shown in Table 5.

Table 5 - Laying course categories
(Note: this table has been reproduced from Table D1, BS 7533-3)

Laying Course Material Category	Application
IA	Pavements receiving severely channelized traffic, aircraft pavements and bus stations
IB	Industrial pavements Loading bays
II	Adopted highways and other roads Petrol station forecourts Pedestrianization projects regular heavy trafficking Car parks receiving some heavy traffic Footways regularly overridden by vehicular traffic
III	Pedestrianization projects receiving only occasional heavy traffic Car parks receiving no heavy vehicles
IV	Private drives Areas receiving pedestrian traffic only Footways likely to be overridden by no more than occasional vehicular traffic

Laying course aggregate should comply with the particle size distribution (grading) as shown in Tables 6 & 7 (note: these tables have been reproduced from Table D2 and D3, BS 7533-3 for particular applications).

The durability of the laying course is related to the amount of fine particles (0.063mm or less). For example, for highly loaded pavements, such as container yards (laying course category IA) the fines content is limited to 0.3% mass passing the 0.063mm sieve.

Table 6 – Grading for laying course aggregate for conventional pavements (BS EN 12620:2002) Gf85 0/4 *(MP)* fine aggregate)

Sieve Size mm	Percentage by mass passing %
8	100
6.3	95-100
4	85-99
0.5	30-70
0.063 (fines content)	See Table 7 - the value is a function of the application

Table 7 – Fines content of laying course material for conventional pavements

Laying course material category	IA	IB	II	III	IV
Percentage by mass passing 0.063mm	0.3	0.5	1.5	3.0	4.0
BS EN 12620:2002 Fines content category	*f0.3*	*f0.5*	*f1.5*	*f3*	*f4*

Laying course aggregate - permeable pavements

Laying course aggregate, described as a coarse graded 2/6.3 (2 to 6mm) aggregate, should comply with the particle size distribution (grading) as shown in Table 8 (note: this table has been reproduced from Table D6 BS 7533-3.) Unlike conventional pavements, the laying course aggregate can also be used as joint filling aggregate, but advice needs to be sought from the block manufacturer regarding the particle size distribution (grading) suitable to ensure the joints can be satisfactory filled.

Table 8 – Grading for laying course aggregate for permeable pavements (BS EN 12660:2002 Gc 80/20 2/6.3 coarse aggregate)

Sieve Size mm	Percentage by mass passing %
14	100
10	98-100
6.3	80-99
2	0-20
1	0-5
0.063	0-2 (BS EN12620:2002 fines category f2)

Laying course aggregate - flag paving (concrete and stone)

The pavement should be categorised according to the commercial vehicular assessment shown in Table 9 (note: this table has been reproduced from Table 2 BS 7533-4) and the appropriate laying course material selected.

Table 9 Applications and laying course material

Site Category	Standard axles per day	Typical Applications	Aggregate Laying Course	Mortar Laying Course
I	<200	Adopted highways and commercial developments used by a high number of commercial vehicles	X	✓
II	<60	Adopted highways and other roads used by a moderate number of commercial vehicles Petrol station forecourts Pedestrian projects subjected to a regular overrun of commercial vehicular traffic	✓	✓
III	<5	Adopted highways and other road used by a low number of commercial vehicles e.g. cul-de-sac on a housing development Pedestrian projects subjected to occasional overrun of commercial vehicles Car parks receiving occasional commercial vehicular traffic Footways overridden by commercial vehicular traffic	✓	✓
IV	0	Car parks receiving no commercial vehicular traffic Footways subjected to domestic vehicular crossover Private drives, paths, patios, hard landscaping Areas receiving pedestrian traffic only, e.g. school playgrounds	✓	✓

Laying course sand should comply with the particle size distribution (grading) as shown in Table 10 (note: this table has been reproduced from Table 5, BS 7533-4.)

Table 10 Laying course aggregate grading for flag pavements (BS EN 12620:2002 Gf 85 0/4 (MP) fine aggregate

Sieve Size mm	Percentage by mass passing %
8	100
6.3	95-100
4	85-99
0.5	30-70
0.063	0-3

Laying course aggregate - sawn setts

For sawn setts the laying course aggregate (naturally occurring and sea–dredged sands) should comply with the particle size distribution (grading) as shown in Table 11 (note: this table has been reproduced from Table C1, BS 7533-7).

Table 11 – Grading for laying course aggregate for non-rigid laying of sawn paving setts (BS EN 12620:2002) Gf85 0/4 (MP) fine aggregate)

Sieve Size mm	Percentage by mass passing %
10	100
6.3	80 - 99
2	0 - 20
1	0 - 5
0.063 (fines content)	0 - 2

Preparing the Laying Course

Block and clay paving

For concrete block and clay paving, BS 7533-3, gives two options for preparing the laying course:

1. Spread the laying course, compact using a plate compactor and then screed. This the preferred method for:
    - machine laying - there is less tendency for the block clusters "digging in" during the laying operation.
    - permeable pavements, if no upper geotextile is used - this helps with "blinding" the sub-base aggregate with laying course aggregate, to avoid long term migration of the laying course into the sub-base.
2. Spread the laying course, and screed un-compacted laying course. This the preferred method for:
    - hand laid concrete blocks, although the pre-compaction method may also be utilised, and clay blocks.
    - block patterns made up of different size blocks made in different production runs, as there is a greater probability of variation with the ± 3mm thickness variance.

Flag paving (concrete and stone)

For flag paving, BS 7533-4 recommends:

(a) Spread the material in one layer and compact this layer using a plate compactor. Then the top 10 mm should be loosened using a rake.

(b) Alternatively, 25 mm of laying course material should be screeded out, compacted and then a further 10mm of loose material screeded out.

(c) In order to achieve the target laying course thickness, allowances should be made for the reduction in thickness achieved during compaction. The surface should be levelled by screeding. In areas of mixed paving, e.g. flags and blocks, the flags should determine the thickness of the laying course.

However the practices described for block paving can also be used.

Sawn Setts

For sawn sett paving, BS 7533-7 recommends:

- Spread the laying course and screed un-compacted laying course.

Screeding the Laying Course

- The thickness and smoothness of the laying course is achieved by dragging a screed, either manually of mechanically, along screed rails that are laid directly on top of the base.
- Screed rails are steel rectangular or round bars or tubes, and of appropriate size to ensure the correct depth of laying course after screeding but with an allowance to account for the compaction of the laying course after the paving has been laid.
- Alternatively, the bulk of the area can have the laying course laid with an asphalt paver, but there will be small areas that need completing, usually by hand.
- The laying course should have a thickness after compaction of the paving units as shown in Table 12.

Table 12 - Laying course thicknesses

	Conventional Paving (non-permeable paving)	Permeable Paving	Flag Paving	Sawn Setts
Laying course thickness after compaction	30 mm, +10, -5mm	50mm ± 20mm	25 +	40mm ± 1mm

- It is permissible to screed from the already prepared laying course to infill against obstructions/edges. This is best achieved by using a lightweight (aluminium) thin flat screed rail laid on the screed laying course.
- Screed relative to datums to ensure the paving is at a constant height against edges/drainage.
- Smooth transitions at changes of gradient, such as at the crown of the road or at inverts, to avoid the potential for spalling and non-conforming large joints.
- Prior to the paving laying operation, all screed rails need to be removed and screed rail trenches infilled and screeded level.
- Any disturbed areas of prepared laying course must be rectified prior to paving unit laying.
- At the cessation of the daily laying activity, areas of prepared laying course should not significantly extend past the paved areas.
- At the cessation of the daily laying activity, all works should be completed no less than 1m from the laying face.

Block, Flag and Sawn Sett Installation

Protection of the works
It is important to ensure that, during the laying operation and prior to completion of the jointing operation, the pavement surface is not contaminated by soil or other construction debris. In addition to this requirement, permeable pavements must be kept clean post-construction to ensure continuous permeability during the lifetime of the pavement.

Re using existing paving units
If it is intended to use second hand, recycled or existing (reinstated) paving units, then they shall be cleaned to remove all traces of laying and jointing aggregate and any other contaminants.

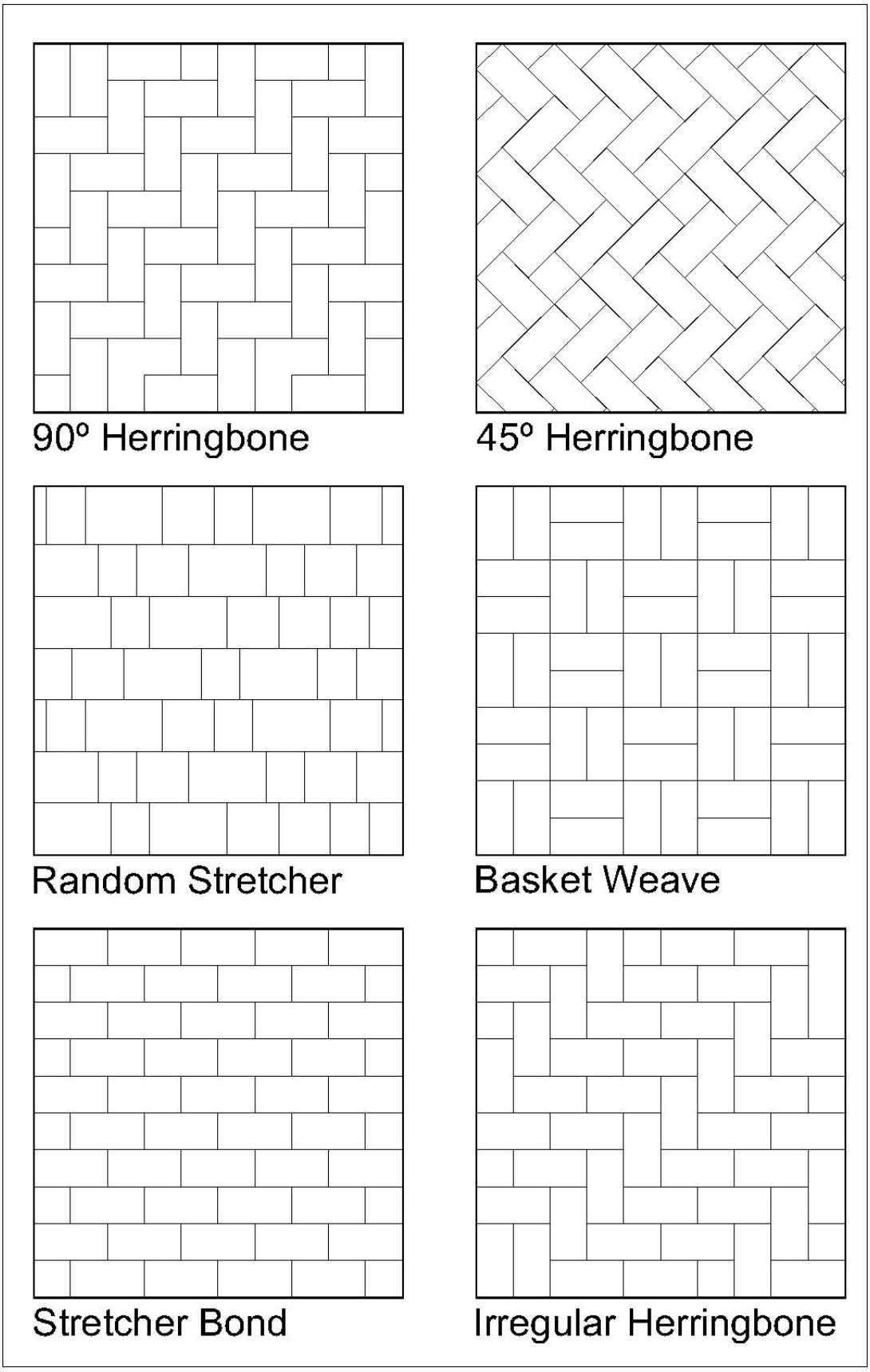
Laying patterns
There are 3 basic laying patterns for paving units generally with a 2:1 length:width module:

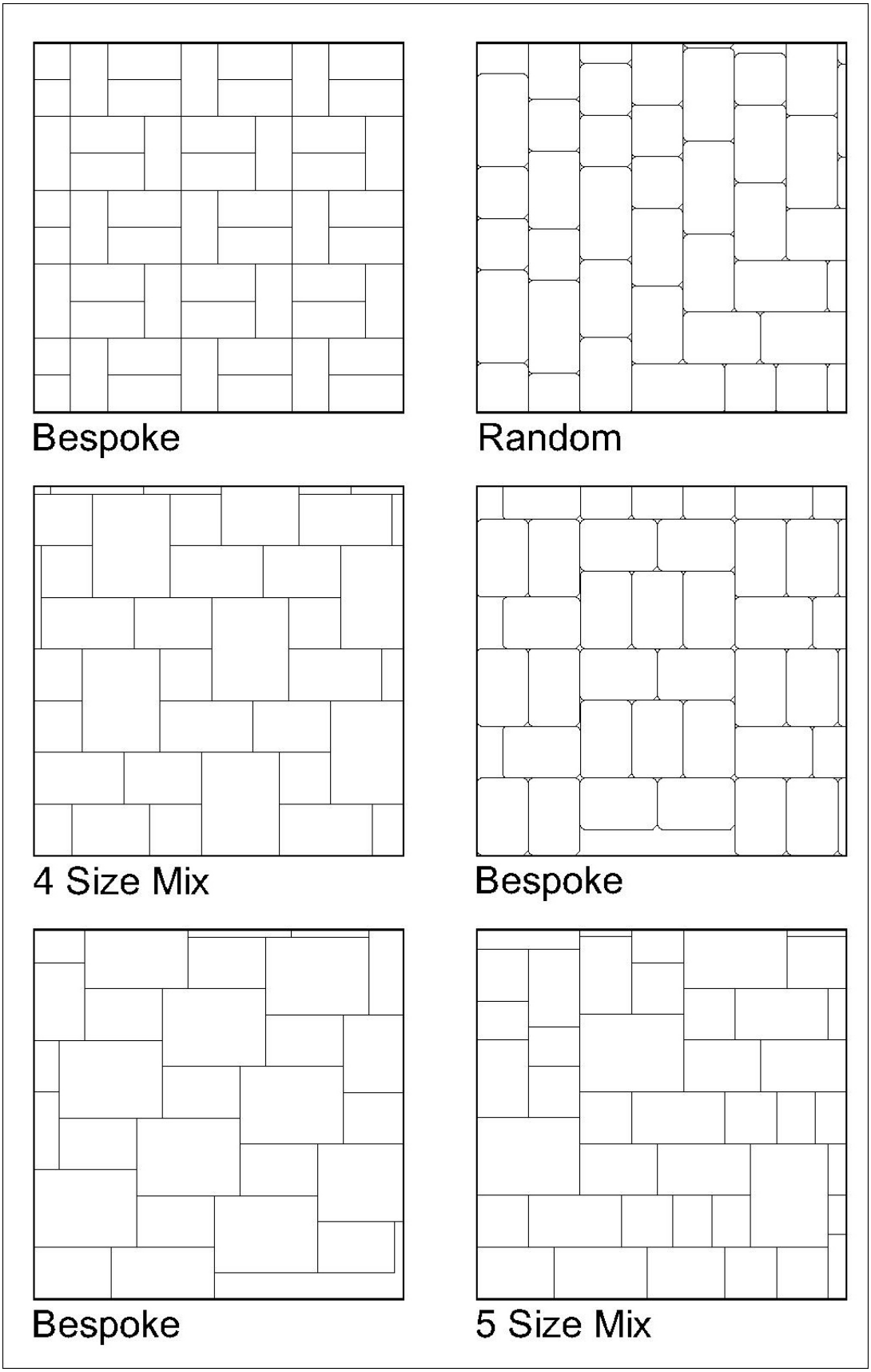
- herringbone
- basket weave (parquet)
- stretcher bond

The strongest laying pattern is herringbone - this pattern is recommended for trafficked situations. There are also numerous patterns for proprietary blocks/systems or where combinations of different block types are specified. Information on proprietary system laying patterns is available from manufacturers.

Lay blocks in the laying pattern specified in the contract documents (specification/drawings). Illustrations of some typical laying patterns follow.

Typical Block Patterns

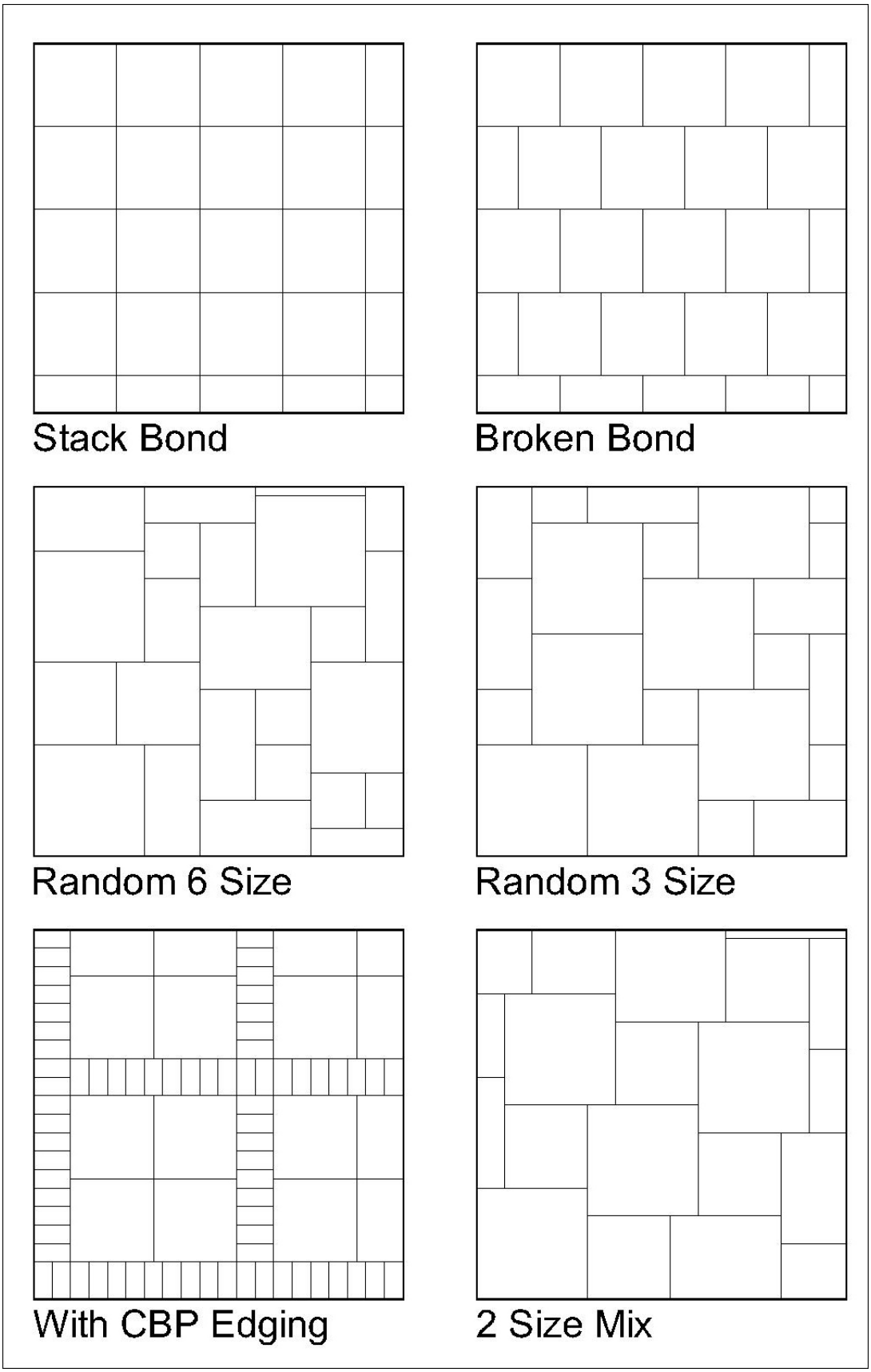




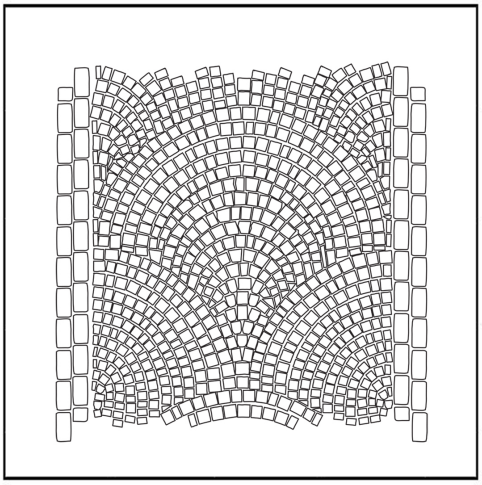
Flag and sett laying patterns

There are many different laying patterns for flags and sett paving, and often block and clay paving may also be incorporated in the laying patterns.

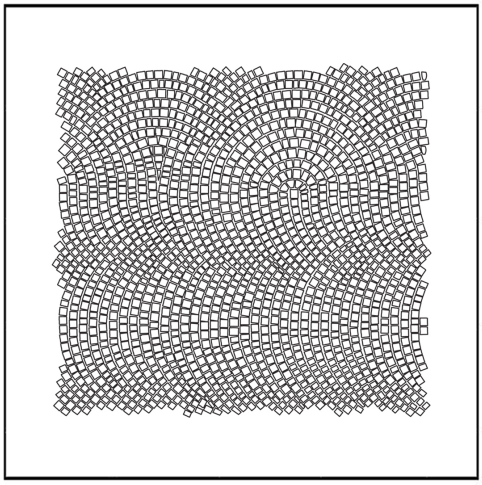
Typical Flag Patterns



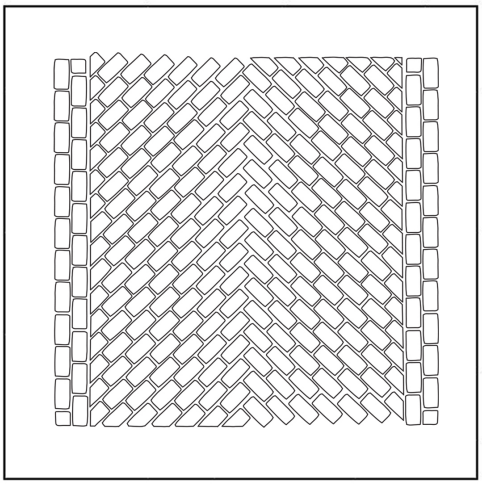
Typical sawn sett patterns



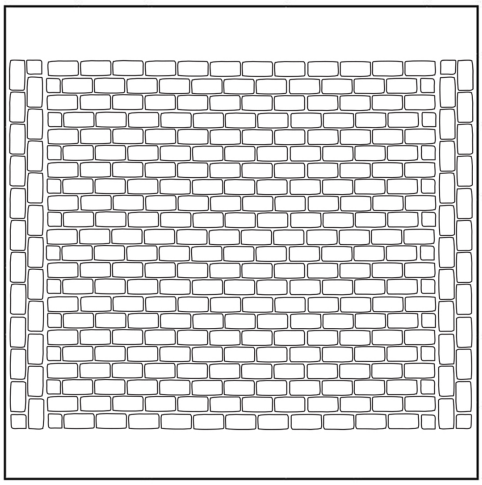
Florentina Pattern – Cube Setts



Segmental Arch Pattern 90° Direction Change – Cube Setts



Chevron Pattern – Setts



Stretcher Bone Pattern – Setts

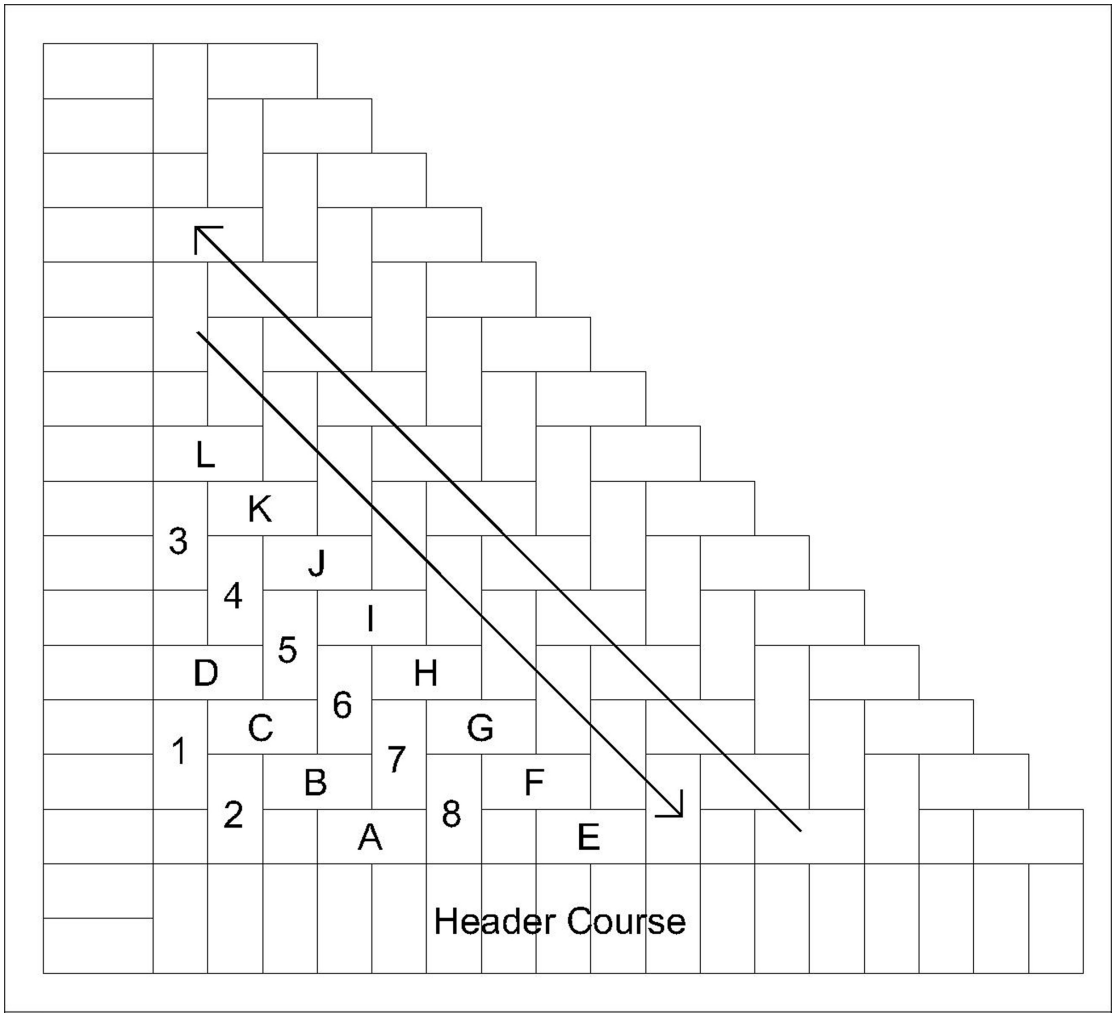
All paving units

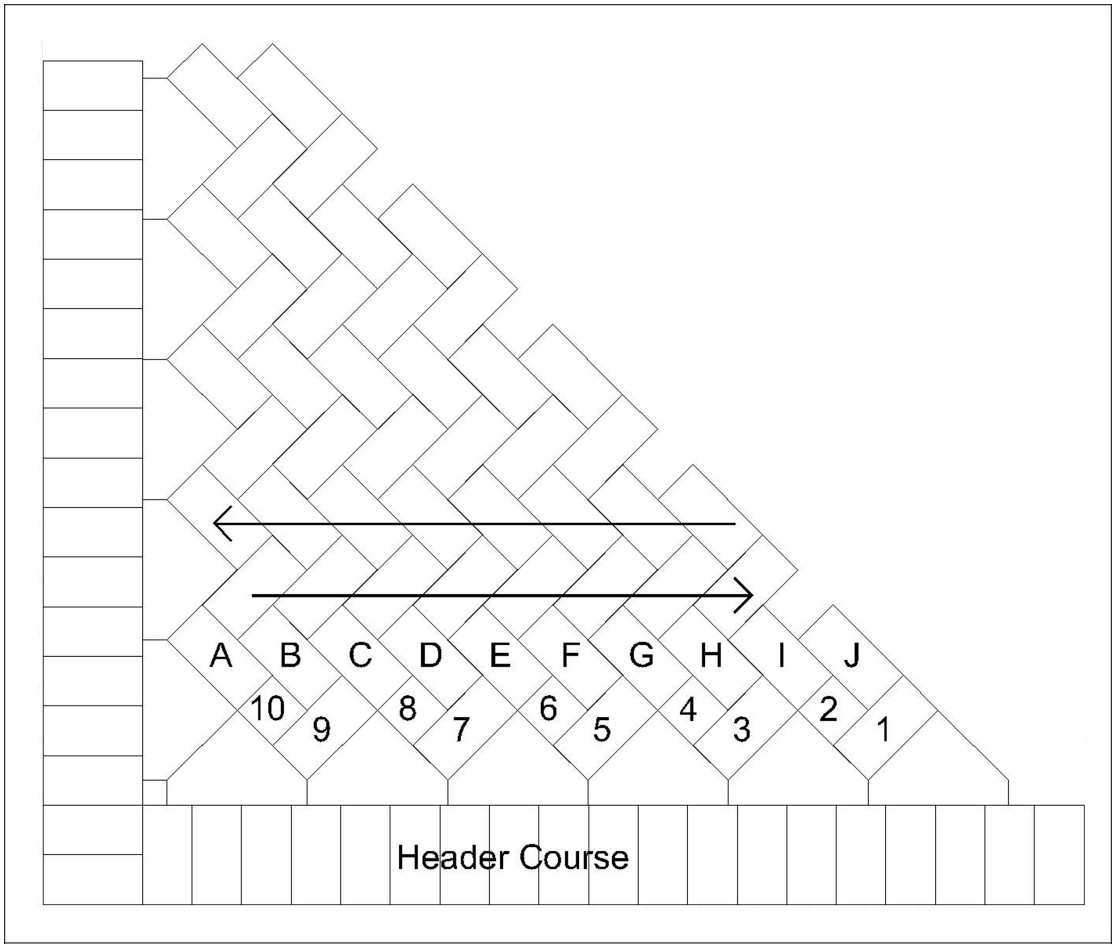
Consideration needs to be given to the orientation of the laying pattern in relation to the surrounding structures. Other considerations are:

- Does the pattern satisfy the designer's intentions?
- Is it possible to minimise cuts?
- Is it possible to set out the paved area in whole paving unit dimension modules?

Block and clay, flag and sett paving units – manual installation

With the exception of infill areas, blocks should be laid to maintain an open laying face - see typical laying procedures below.





If you are not sure of the laying procedure, ask the manufacture to provide a data sheet/laying instructions.

Blocks – mechanical installation

It is possible to machine lay blocks, usually with equipment specifically designed for the task.

- The blocks need to be packaged by the manufacturer in a format suitable for machine laying.
- The manufacturer must provide information on the laying sequence and techniques.

General requirements for laying paving units

- Lay to datum, such as string lines, to assist in maintaining straight lines and compliant joint spaces.
- When laying setts to curves or fanned radii, set a pin at the based of the fan and strike an arc with a string line of constant length.
- Block, clay paving and flag paving units are only placed on the prepared laying course. They are not tapped into place, although some flag paving units may need to be tapped into position.

- Sawn setts are placed on the prepared laying course and then each sett is tapped into place to line and level.
- Manufacturers cannot guarantee consistent colours, due to variations in the colour of raw materials and in the manufacturing process. Therefore, to minimise the effect of batch colour variation, order the paving as a single lot and mix paving from different packs to avoid colour striping.
- Most concrete and clay paving blocks have spacer nibs to achieve a nominal joint space between adjacent blocks.
- For paving units that do not have spacer nibs, care must be taken to ensure that the minimum joint space is achieved.
- Continually check the alignment of the paving units and joint spaces and adjust if necessary to ensure straight lines/constant curves and/or consistent joint spaces.
- Ensure the joint spaces comply with the requirements tabulated in Table 13.

Table 13 - Joint Spaces

	Conventional Paving (non-permeable paving)	Permeable Paving	Flag Paving	Sawn Setts
Joint space (measured at the widest point)	2 to 5 mm	Conforms to the manufacturer's recommendations. (Manufacturers produce different types of block with different nib formats or methods to achieve a joint to allow the infiltration of surface water between blocks)	2 to 5 mm	2 to 4 mm

Cutting in

- Cutting of paving must be undertaken in accordance with Interpave's guidance Cutting Paving (available via www.paving.org.uk)
- Prior to marking the paving for cutting-in at edges and around drainage pits, manholes etc., ensure that the laid paving is correctly aligned. Otherwise, there is a danger that the marking will be incorrect and the paving may need re-marking and re-cutting.
- Complete cutting-in as soon as possible after the paving laying and prior to compacting with a plate compactor.
- Give consideration to header course details: on tight radii the joints between the header blocks will open up. It is preferable not to infill with mortar but to taper-cut the header blocks (usually by diamond saw cutting).

Recommended methods of cutting are tabulated in Table 14.

Table 14 - Suitable methods of cutting paving units

	Chisel & hammer	Bolster & hammer	Guillotine	Bench saw with water suppression	Hand held saw with water suppression
Concrete block	✓	✓	✓	✓	
Clay pavers				✓	
Flag - smooth		✓	✓	✓	✓
Flag - textured, riven or tactile				✓	✓
Sett - sawn		✓		✓	

- Sawn setts with plan dimensions less than 40 to 60mm should not be cut.
- Blocks and clay pavers - cuts less than 25% of the original plan size should be avoided. It is permissible to compromise the laying pattern to minimise small cut pieces.
- Long slender cut pieces for all paving unit types should be avoided.
- It is permissible to infill around obstructions, such as bollards, with concrete. Use either C35 air entrained concrete conforming to BS EN 206-1:2000 or 3:1 mix of BS EN 12620:2002 GC 85/20 6.3/14 coarse graded aggregate. However experience demonstrates that structurally and aesthetically this is not always satisfactory and an alternative solution should be sought.

Prior to compaction

Remove rubbish and all debris prior to compacting.

- Complete edge details (and allow concrete to set) or provide temporary supports.
- Only when using clay paving or concrete paving with no spacer nibs is it permissible to apply a small amount of jointing aggregate (sand) to help maintain the correct minimum joint space prior to compacting. Correct joint spacing and alignment prior to this operation.
- For flag and sawn setts the joints should be totally filled with jointing aggregate (sand) prior to compacting with a plate compactor. Correct joint spacing and alignment prior to this operation.

Compaction process

- Paving should be bedded (compacted) into the laying course with a suitable plate compactor (usually a minimum of two passes of the plate compactor are necessary).
- It may be necessary to protect the surface of the paving to ensure the surfaces are not scuffed or damaged in this process. This is particularly important where the surface of the paving unit has been textured, ground, shot blasted, etc.
- Protecting the paving units from scuffing during the compaction process can be achieved by the use of a protective mat to the underside of the plate compactor.

Table 15 - Compaction Equipment

Site category (See table 5)	Paving unit type	Min. plate area m^2	Min. effective force per unit area of plate kN/m^2	Frequency Hz	Min. mass kg
I & II	Block	0.25	75	65 - 100	200
III & IV	Block, clay paver, flags & setts	0.2	60	75 - 100	80

Compliance checks

After compaction check that the following aspects of the works are compliant at this stage (see Table 16 for a summary of criteria):

- Joint spaces - joints between blocks
- Surface levels - see Table 16 for recommendations
- Lipping - relative height between blocks
- Surface smoothness - the smoothness of the pavement surface
- Cutting in (complete as you go)
- Damaged or defective blocks - remove and replace

Table 16 - Summary of key compliance criteria

Compliance criteria	Conventional Paving (non-permeable paving)	Permeable Paving	Flag Paving	Sawn Setts
Joint space (measured at the widest point)	2 to 5 mm	Conforms to the manufacturer's recommendations. (Manufacturers produce different types of block with different nib formats or methods to achieve a joint to allow the infiltration of surface water between block)	2 to 5 mm	2 to 4 mm
Lipping - relative height between blocks	2 mm	2 mm	2 mm (not applicable to riven finishes)	No requirement
Surface smoothness - the smoothness of the pavement surface	10 mm measured under a 3m straight edge (note: this criteria is not applicable at changes of gradient)	No requirement	3 mm measured under a 3m straight edge (not applicable to riven finishes). (Note: this criteria is not applicable at changes of gradient)	No requirement
Cutting in	Cut pieces less than a quarter & long slender cuts should be avoided	Cut pieces less than a quarter & long slender cuts should be avoided	Cut pieces less than a quarter & long slender cuts should be avoided	Cut pieces less than a third should be avoided, no plan dimension less than 50mm
Damaged or defective blocks	Remove and replace any visually apparent damaged blocks	Remove and replace any visually apparent damaged blocks	Remove and replace any visually apparent damaged blocks	Remove and replace any visually apparent damaged blocks
Surface level (The British Standard states ± 6 mm, but a more pragmatic approach to visually assess levels and smoothness in relation to adjacent areas and structures may be appropriate. In the case of conventional paving (non permeable paving) there should be no evidence of water ponding)	± 6 mm	± 6 mm	± 6 mm	± 6 mm

Joint spaces and alignment

Inspect and, if necessary, adjust the paving units to ensure compliant joint spaces and alignment.

Lipping

If any lipping is non-compliant then the cause needs to be investigated and corrections made.

Possible causes of lipping:

- Variable paving unit thickness. For example, the manufacturing tolerance for block thickness is ± 3mm; if, however, the blocks vary significantly within the tolerance, then it will still be difficult to achieve a smooth pavement surface.
- Contamination of the laying course with large aggregate pieces.
- Incorrect screeding of the laying course or the laying course was disturbed prior to laying of the paving units.
- Insufficient compaction of the paving units into the laying course.

Suggested methods of correcting lipping:

- Re-compact to resolve problem
- Remove paving units and adjust laying course. If it proves necessary to significantly adjust/replace the laying course, then re-compact the paving units into the laying course.

Surface smoothness (conventional concrete blocks, clay pavers and flags)

The surface smoothness is checked with a 3m straight edge and the deviations under this straight edge measured with a measuring wedge or rule/tape. An experienced operative may be able to visually assess and identify any non compliant areas.

- Non compliant areas can be corrected by removing an area of paving units, re-profiling the laying course and relaying the paving units. If it proves necessary to significantly adjust/replace the laying course, then re-compact the paving units into the laying course.

Cutting in and damaged or defective paving units

- Visually assess and rework/correct.

Jointing operation

- For concrete blocks - only if all the proceeding work is compliant should the jointing operation be allowed to proceed.
- For blocks with no spacer nibs, clay pavers, flags and setts: where the joints have been partially or totally filled with jointing aggregate, only if all the preceding work is compliant should the jointing operation be completed.
- There should be no material or debris on the surface of the pavement prior to starting the jointing operation, so as to avoid contaminating the joints.
- Ideally, the paving units should be dry to allow complete filling of the joints. If, however, this is not possible topping up and re compacting of the joints may be necessary.
- On completion of the jointing operation, the joints should be completely filled with the appropriate aggregate.
- For sett paving, the joints should have been completely filled prior to the compacting operation but this joint filling aggregate will compact into the joints during this operation. Fine topping aggregate should therefore be spread over the surface to a thickness of 5 to 10mm. Then, to ensure the joints are completely filled, the surface should be sprayed with a fine water spray to wash the aggregate into the joints.
- For permeable pavements any loose jointing aggregate must be removed from the pavement surface prior to compacting, otherwise it can be crushed, damaging and scouring the surface of the blocks.
- The complete surface will need to be compacted with the same type of plate compactor that is used to compact the blocks into the laying course.

Blocks, clay paving, flags and sawn setts - conventional (non-permeable pavements) jointing aggregate

The jointing aggregate is fine sand, usually kiln dried so it flows easily into the joints. This sand can be supplied loose and delivered by tipper, in bulk bags with a pouring shute at the bottom of the bag or in 25kg bags. The grading requirements should comply with Table 17 (note: this table has been reproduced from table D4, BS 7533-3; the grading requirements for flags and sawn setts are identical).

Table 17 – Grading for jointing aggregate for conventional pavements (BS EN 12620:2002 Gf 85/01 (FP) fine aggregate)

Sieve Size mm	Percentage by mass passing %
2	100
1	85-99
0.5	55-100
0.063 (fines content)	0-2 (BS EN 12620:2002 fines category f2)

Conventional pavements with non-parallel joints, e.g. where the sides of the paving unit are curved, should be filled with material that is recommended by the manufacturer as suitable.

Blocks and clay paving - permeable pavement jointing aggregate

The jointing aggregate can be the same as for the laying course, described as a 2/6.3 aggregate. This aggregate can be supplied loose and delivered by tipper, in bulk bags with a pouring shute at the bottom of the bag or in 25kg bags. The grading requirements should comply with Table 18 (note: this table has been reproduced from table D6, BS 7533-3)

Table 18 – Grading for laying course material for permeable pavements (BS EN 12620:2002 (GC) 80/20 2/6.3 coarse aggregate)

Sieve Size mm	Percentage by mass passing %
14	100
10	95-100
6.3	80-99
2	0-20
1	0-5
0.063	0-2 (BS EN12620:2002 fines category f2)

Although the laying course aggregate can also be used as jointing aggregate it is recommended to check that the aggregate can easily fill the joints.

Final compliance checks

After compaction of the joint aggregate, the previous compliance checks are repeated, covering the following:

- Joint spaces - joints between blocks
- Surface levels see table 16 for recommendations
- Lipping - relative height between blocks
- Surface smoothness - the smoothness of the pavement surface
- Cutting in (complete as you go)
- Damaged or defective blocks - remove and replace.

Finally:

- Correct any non compliances and re-inspect
- On satisfactory completion of all the work tasks, followed by clearing and cleaning the work and storage areas, the work can be declared as complete.

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